INCIDENCE OF LOWER LIMB FRACTURES AMONG REHABILITATED CHRONIC TRAUMATIC SPINAL CORD INJURY PATIENTS OF T10 NEUROLOGICAL LEVEL AND BELOW

Dissertation submitted to the Tamil Nadu Dr. M.G.R Medical University, Chennai, Tamil Nadu in partial fulfillment of the requirements for the MD branch XIX (Physical Medicine and Rehabilitation) University Examinations in May 2019

CERTIFICATE

This is to certify that the thesis titled **"Incidence of lower limb fractures among rehabilitated chronic traumatic spinal cord injury patients of T10 neurological level and below"** is the bonafide work of **Dr. Naveen Cherian Thomas**, candidate number **201629053** in fulfillment of the requirement of the Tamil Nadu Dr M.G.R Medical University, Chennai, Tamil Nadu for the MD branch XIX(Physical Medicine and Rehabilitation) University examinations in May 2019.

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DECLARATION

This is to certify that this dissertation titled **"Incidence of lower limb fractures among rehabilitated chronic traumatic spinal cord injury patients of T10 neurological level and below "** is submitted by me in partial fulfilment towards M.D. in Physical Medicine and Rehabilitation (Branch XIX) examination of the Tamil Nadu Dr. M.G.R Medical university, to be held in May 2019

I have independently reviewed the literature, standardized the data collection methodology and carried out the evaluation towards completion of the thesis.

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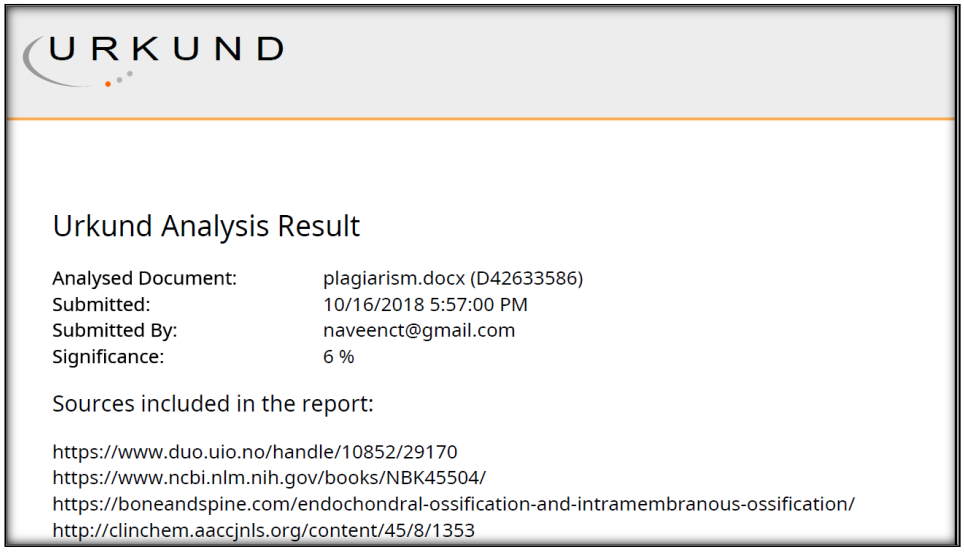

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ABSTRACT

TITLE : Incidence of lower limb fractures among rehabilitated chronic traumatic spinal cord injury patients at T10 neurological level and below.

DEPARTMENT : Physical Medicine and Rehabilitation

NAME OF THE CANDIDATE : Dr. Naveen Cherian Thomas

DEGREE AND SUBJECT : MD, PMR

NAME OF THE GUIDE : Dr. Jacob George

OBJECTIVE : To find the incidence of fractures among rehabilitated chronic traumatic SCI patients at T10 neurological level and below. To identify the people who are functionally ambulating after rehabilitation training, risk of falls , benefits associated with functional walking.

METHODS : Its a cohort study. Seventy patients were enrolled for a period of one year from 2017 – 2018. Detailed questionnaire and clinical examination were done to find out the outcomes . Students t-test for continous variables and Chi- square test for categorical variables were done.

RESULTS : No incidence of fractures were noted. Non walkers are more at risk of fall than walkers.

CONTENTS

CONTENTS

AIM

- To find the incidence of lower limb fractures among rehabilitated chronic traumatic spinal cord injury patients at T10 neurological level and below.

OBJECTIVES

Primary Objective

- To find the incidence of lower limb fractures among rehabilitated chronic traumatic spinal cord injury patients at T10 neurological level and below.

Secondary Objective

- Identify the people who are functionally ambulating after rehabilitation training.
- Identify the risk of falls .
- To identify the benefits associated with functional walking.
- To establish a relationship between fractures and functional walking.

INTRODUCTION

Spinal cord injury results in sensory and motor dysfunction, leading to impairment in locomotion, bowel, bladder and sexual functions. These injuries can occur due to motor vehicle accidents, falls, violence, sports injuries, firearm injuries and non-traumatic spinal cord injuries like infections, tumor, musculoskeletal disease like osteoarthritis and congenital problems such as spina bifida. (1)

According to WHO International Spinal Cord Society 2013, the incidence data suggests that every year between 2,50,000 and 5,00,000 people become spinal cord injured. Majority is traumatic spinal cord injury, the leading cause are RTA , falls and violence.

The symptoms of spinal cord injury lesions depend on the extent of the injury or non-traumatic cause, but they can include loss of sensory or motor control of the lower limbs, trunk and the upper limbs as well as loss of autonomic regulation of the body. This can effect breathing, heart rate, blood pressure, temperature control, bowel and bladder control and sexual function (2).

Long bone fractures are a common secondary complication of spinal cord injury. The diagnosis of a fracture in an anaesthetic limb can be a challenge. Most patients present with recent history of unilateral leg swelling, malaise and low grade fever. On clinical examination a local swelling or a bruise might be present. The lower extremities are predominantly affected by fractures and are typically located in the diaphyseal or distal femur and in the proximal lower leg. Typically SCI individuals suffer from fragility fractures that is low energy fractures(3,4). The extensive loss of bone mass in the paralysed

extremities is a main factor contributing to the increased fracture risk after SCI. Within the first years after motor complete SCI, bone mineral density decreases by 50-70% in the lower extremities. This loss of bone density is paralleled by an overall increased fracture rate after SCI. Complications that commonly arise after a fracture are decubitus ulcers, venous thromboembolic events, mal-alignment, non-union or malunion(5).

THERAPEUTIC INTERVENTION

Rehabilitation Medicine plays a vital role in preventing complications and helping the patients to have the same life expectancy as normal people. One of the major interventions include functional ambulation using orthosis. Functional ambulation is the ability to walk with the aid of appropriate assistive devices (orthosis), safely and sufficiently to carry out mobility related activities of daily living. The orthosis used in our department for functional ambulation in spinal cord injury are bilateral knee ankle foot orthosis(KAFO), walkers, axillary crutches and elbow crutches. Depending upon the neurological level and the progress in rehabilitation training, the orthosis will be prescribed.

JUSTIFICATION OF THE STUDY

Incidence of sublesional fractures are very high in spinal cord injury patients. Studies report about 25% SCI patients have fractures below the level of lesion (6). Within the first years after motor complete SCI, bone mineral density decreases by 50-70% in the lower extremities. This loss of bone density is paralleled by an overall increased fracture rate after SCI. Since these fractures may be asymptomatic yet may lead to complications, preventing and managing 'neurological osteoporosis' remains a considerable challenge. Complications due to fractures lead to increased mortality and morbidity. Osteoporosis and Osteopenia are inevitable complications following a spinal cord injury. Thus there is a need for early rehabilitation among the spinal cord injury patients and especially to make them functionally walk with orthosis based on their neurological level. This study looks into how functional walking reduces the incidence of fractures in spinal cord injury patients who are T10 neurological level and below.

LITERATURE REVIEW

BONE – INTRODUCTION

Bone is a mineralized connective tissue and one of the hardest substances in the body. Bony skeleton is a remarkable organ which forms the primary structural framework for support and protection of the organs in the body. The adult human skeleton has about 213 bones, excluding the sesamoid bones. The appendicular skeleton has 126 bones, axial skeleton 74 bones, and 6 auditory ossicles**.** (7)

BONE STRUCTURE

Bones can be classified based on the structure into 2 main types-

CORTICAL BONE - is a dense, solid bone which surrounds the marrow space and composed of units called osteons, also called as Haversian Systems. Haversian systems are cylindrical in shape and form a branching network within the cortical bone. Concentric layers of lamellar bone form the walls of Haversian canals. Cortical bone has an outer periosteal surface and inner endosteal surface. The endosteal surface has higher remodeling activity than the periosteal surface, most likely due to greater biomechanical strain or greater inflammatory exposure from the adjacent bone marrow.

TRABECULAR BONE – Trabecular bone is composed of a honeycomb like network of trabecular plates and rods interspersed in the bone marrow compartment. (Fig. 1) Trabecular osteons are also called packets. The plates and rods on an average have 50 to 400mm of thickness. Trabecular osteons are semilunar in shape, about 35 mm thick and

composed of concentric lamellae. The adult human skeleton is composed of 80% cortical bone and 20% trabecular bone(8).

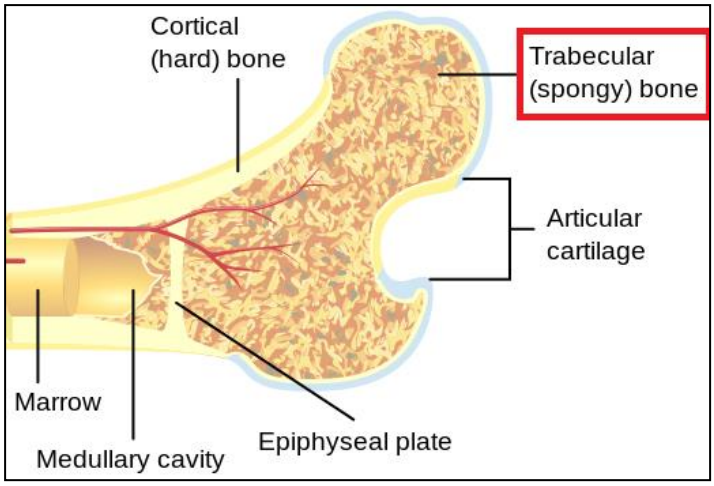


Figure. 1: Longitudinal section of long bone depicting cortical and trabecular

Bone is principally composed of

A. Inorganic salts and
B. Organic matrix.

The **organic matrix** comprises of collagenous proteins (90%), and noncollagenous matrix proteins like osteocalcin, osteonectin, osteopontin, fibronectin and bone sialoprotein II, bone morphogenetic proteins, and growth factors.

The **inorganic portion** of bone consists chiefly of phosphate and calcium ions. Calcium and phosphate ions nucleate to form the hydroxyapatite crystals. Together with collagen, the noncollagenous matrix proteins form a scaffold for hydroxyapatite deposition and such association is responsible for the typical stiffness and resistance of bone tissue.

The long bones are composed of

i. A hollow shaft, or **diaphysis**;

ii. Flared, cone-shaped **metaphyses** below the growth plates; and

iii. Rounded **epiphyses** above the growth plates.(7) (Fig. 2)

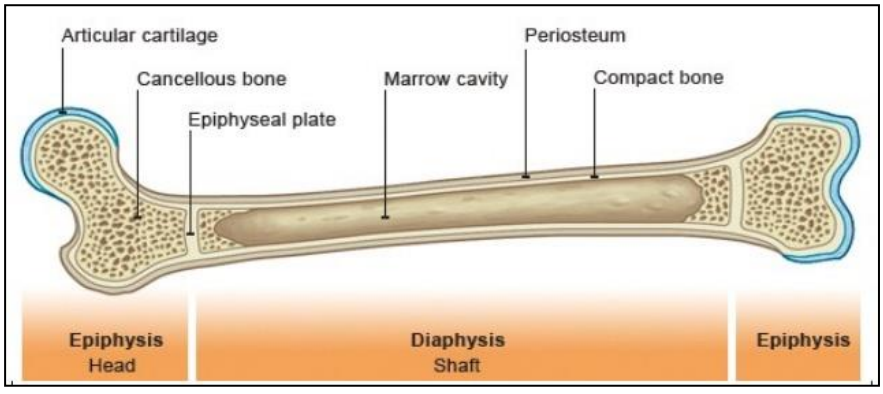


Figure. 2: Longitudinal section of long bone depicting parts of long bone.

The diaphysis is composed primarily of dense cortical bone, whereas the metaphysis and epiphysis are composed of trabecular meshwork bone surrounded by a relatively thin shell of dense cortical bone.

BONE MEMBRANES: PERIOSTEUM AND ENDOSTEUM

The **periosteum** is a double layered protective membrane , comprising of an outer dense fibrous connective tissue layer and inner osteogenic layers comprising of bone cells. The inner layer is richly supplied by nerve fibres, blood vessels and lymphatics which enter the bone via nutrient foramina. Sharpey's fibres are thick collagenous fibrous strands which tightly bind the periosteum and outer cortical surface together. The **endosteum** cover the inner surface of cortical and trabecular bone, Volkmann's canal. It is in contact with the bone marrow space and contains blood vessels, osteoblasts and osteoclasts (9).

BONE MICRO STURCTURE AND CHEMISTRY

Bone tissue is composed of a mineral phase in an organic matrix mainly constituted by type 1 collagen fibril. It comprises of 50-70 % mineral, 20-40 % organic matrix , 5-10 % water , 3% lipids. Bone mineral is structurally related to naturally occurring geological mineral hydroxyapatite [Ca 10(PO4)6(OH)2], differing in crystalline size, perfection and content of impurities (Mg+2, Sr+2, CO3 2-, H P O 4 2-) (Fig 3). In human bone , mineral is composed of a poorly crystallized , calcium deficient and non stoichiometric apatite. It contains major elements like Ca2+, (40 wt%), PO4 3-(18wt %), CO3 2-(6-7wt %), minor elements as Mg2+ or Na+ and trace elements (Sr2+, F-). It is a reservoir of ions that can be stored or released by the means of remodeling to maintain phosphocalcicequilibrium.(10)

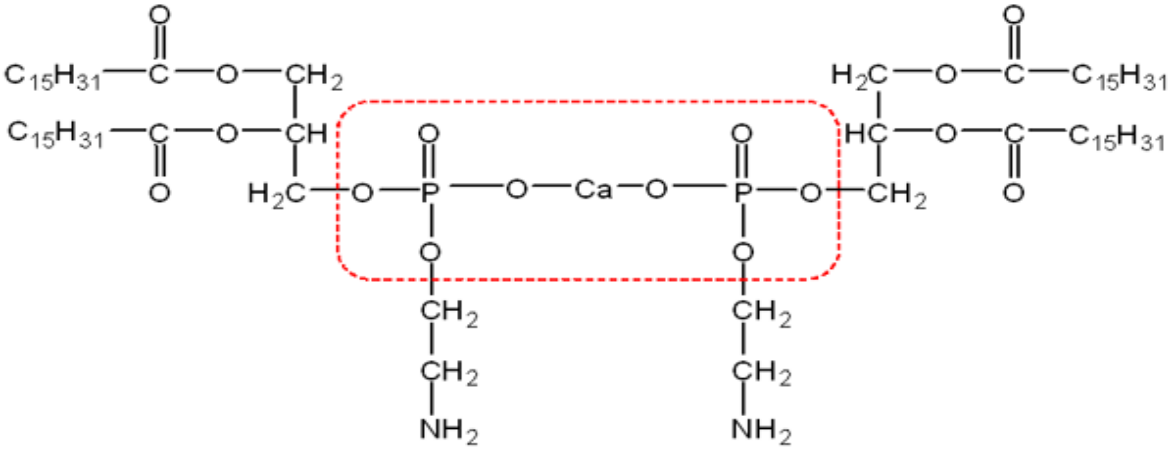


Figure 3: Hydroxyapatite crystal structure showing the calcium moiety and the phosphate with the carboxyl group attached.

Mineral crystallites are nano- sized platelet- shaped (1-7nm in thickness, 15-200 nm in length and 10-80 nm in width). Their organization in bone tissue depends on the structural

properties of organic matrix , which includes collagen that acts as a template for mineral deposition and the distribution of other matrix proteins . Diet, age, mineral turnover , cell viability, health status and the use of the therapeutic modalities also affect the crystal size and mineralisation. The mineral crystals are arranged parallel to each other and crystallographic c-axis of the apatite is oriented parallel to the longitudinal axis of the collagen fibrils in a staggered arrangement, with the first nucleation within the gap zones of collagen fribrils. Crystal nucleation is triggered by collagen and by non collagenous proteins , which also regulate several steps of mineralization. Bone minerals provides mechanical rigidity and load bearing strength. Organic matrix provides elasticity and flexibility.

Bone crystals can be depicted in three compartments : surrounding fluid, hydrated layer and apatitic core (Figure 4). Ions in the hydrated layer are very labile and reactive and constitute the non apatitic domains (HPO42-, PO43-, CO3 2-). During mineral maturation, non apatitic domains exchange readily and reversibly with the apatitic domain which is associated with an increase in stable apatitic core. The presence of apatite enhances the tensile modulus and strength of collagen where as organic matrix directly acts on the proportions of loads transferred on mineral particles preventing mineral cracking. The quality of bone mineral can be described by its crystalline nature, maturity and level of substitution. Crystallinity encompasses the size and perfection of the crystal lattice, i.e the degree of order of the ions constituting the lattice and is therefore sensitive to the size and

strain of crystals. The mineral maturity reflects the conversion of nonapatitic precursors into apatitic mineral. (11)

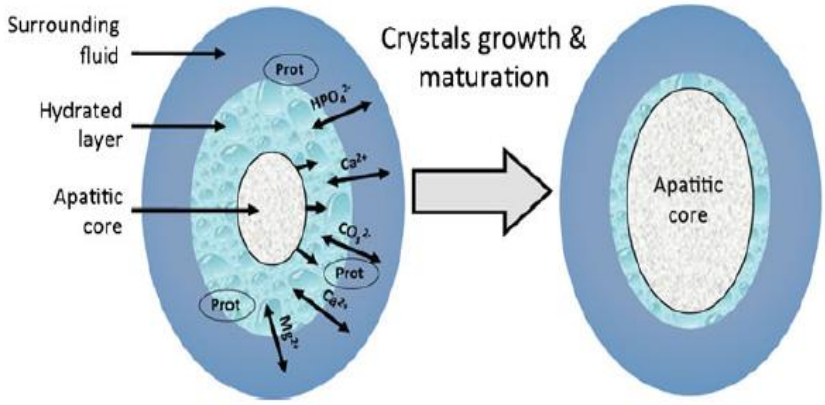


Figure 4: Evolution of the hydrated layer and apatite core during the growth and the maturation of

FUNCTIONS OF BONE

It is not a static organ, but is constantly changing to better carry out its functions. The classical functions of bones are:

i. They provide structural support for the body,

ii. They permit movement and locomotion by providing levers for muscles,

iii. They protect vital internal organs and structures,

iv. They maintain mineral homeostasis and acid-base balance, and

v. They provide the milieu for hematopoiesis within the marrow spaces.(7)

Additionally, bone is also involved in **endocrine functions** which are able to affect other organs. For instance, osteocalcin produced by osteoblasts act on other organs (12). In pancreas, osteocalcin acts as a positive regulator of pancreatic insulin secretion and the proliferation of pancreatic β-cells. In the adipose tissue, osteocalcin enhances insulin sensitivity etc.(13)

Another endocrine function of bone tissue is by osteocytes. These cells are able to regulate phosphate metabolism, which acts on other organs including parathyroid gland and kidneys to reduce the circulating levels of phosphates. (14)

BONE CELLS

Bone is primarily composed of 4 types of cells lying in an extracellular matrix (ECM), they are:

1. Osteoblasts
2. Osteoclasts
3. Osteocyte
4. Bone lining cells .(15,16) (Fig. 3)

Bone is continuously remodeled through the rigorous actions of these bone cells.

OSTEOBLASTS

Osteoblasts are cuboidal cells that are located along the bone surface comprising 4–6% of the total resident bone cells and are largely known for their bone forming function. They originate from the osteoprogenitor cells. They synthesize new bone matrix on bone forming surfaces, the osteocytes within bone matrix and the protective lining cells that cover the surface of quiescent bone (17). Active mature osteoblasts synthesize bone matrix. Osteoblasts secrete type 1 collagen and matrix proteins which contributes towards bone surface formation.(7)

OSTEOCLASTS

Osteoclasts are large motile, multinucleated cells which facilitate bone resorption. Osteoclasts attach to bone matrix via integrin receptors on the osteoclast membrane linked by bone matrix peptides. Osteoclasts bind to the bone matrix and becomes polarized , with

the bone resorbing surface developing a ruffled border (18). The ruffled border secretes H+ ions via H-ATPase and chloride channels and exocytosis of lysozymes and cathepsin K which degrades collagen in the acidified vesicles (17). A sealing zone around the periphery of osteoclast attachment to the matrix is formed which isolates the acidified resorption compartment from the surrounding bone surface.(7)

OSTEOCYTES

Osteocytes forms 90–95% of the total bone cells. They are the most abundant and long-lived cells, with a lifespan of up to 25 years. They act as mechanosensors and orchestrators of the bone remodeling process. (7,19) . They are terminally differentiated osteoblasts, positioned between lamellae in a concentric pattern around the central lumen of osteons. Osteocytes are connected with each other and the surface via multiple cilia like cellular process. Osteocytes transduce stress signals, like stretching of bone into biologic activity, by means of flow of fluid within the canalicular channels. (20) This in turn induces a variety of responses within osteocytes. Transmission of information between surface osteoblasts and osteocytes may be through calcium fluxes via gap junctions or ion channels (Figure 5). Osteocytes live for decades in low remodelling states, acting as mechanosensors , but undergo apoptosis once there is disruption of intercellular networks or gap junctions. Oestrogen therapy and mechanical loading of bone may help prevent osteoblast and osteocyte apoptosis.(21)

Bone lining cells are quiescent flat osteoblasts that cover the bone surfaces and play an important role in coupling bone resorption to bone formation. (22)

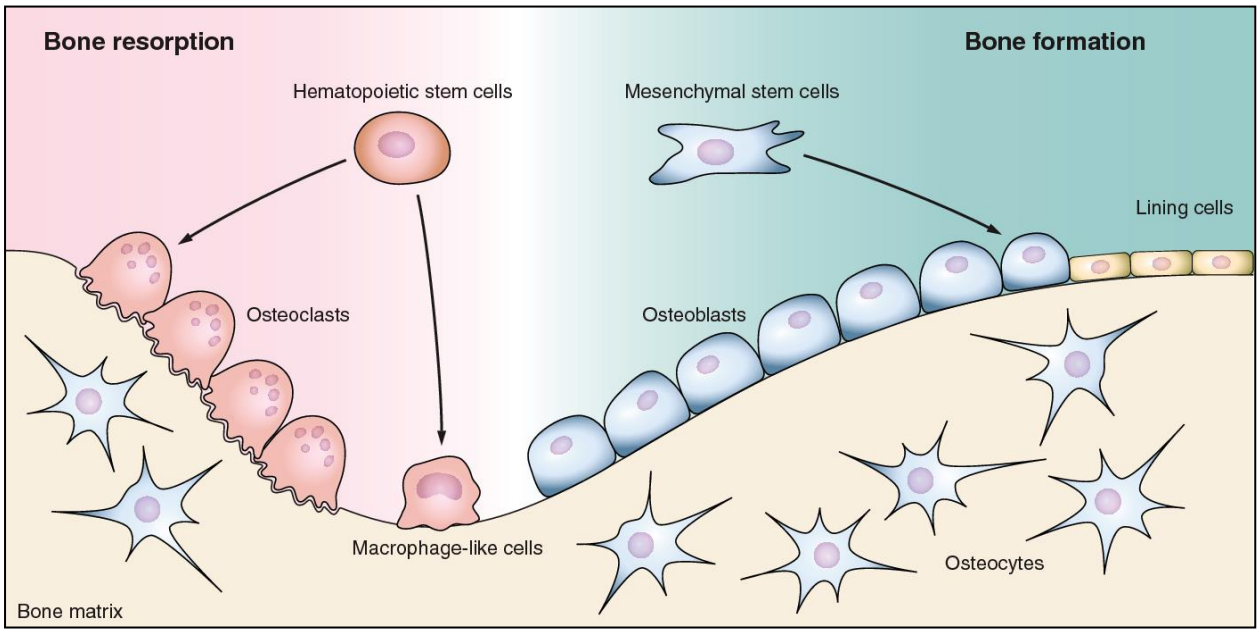


Figure. 5 : Schematic image depicting various bone cells.

Normal bone remodeling is necessary for skeletal adaptation to mechanical use, as well as for calcium homeostasis, an imbalance between bone resorption and formation results in several bone diseases. For example, excessive resorption by osteoclasts without the corresponding amount of neoformed bone by osteoblasts contributes to bone loss and **osteoporosis**, whereas the contrary may result in **osteopetrosis.**

Thus, the equilibrium between bone formation and resorption is necessary and depends on the action of several local and systemic factors including hormones, cytokines, chemokines, and biomechanical stimulation.(23)

BONE FORMATION

Although histologically one bone is no different from another, bone formation occurs by three main mechanisms:

1. Endochondral,
2. Intramembranous, and
3. Sutural.

Endochondral bone formation takes place when cartilage is replaced by bone. It occurs at the extremities of all long bones, in vertebrae, and in ribs and the base of the skull.

Early in embryonic development a condensation of mesenchymal cells occurs. Chondrocytes differentiate from these mesenchymal cells, and a perichondrium forms around the periphery, giving rise to a cartilage model that eventually is replaced by bone.(Fig. 6)

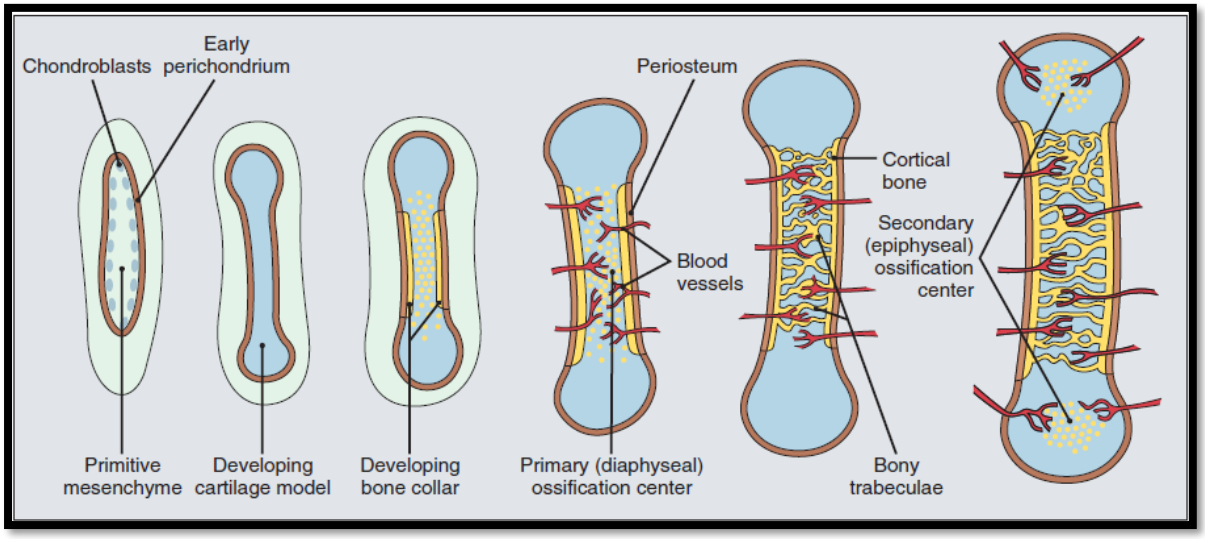


Figure. 6: Schematic image depicting events in endochondral bone formation.

Intramembranous bone formation occurs directly within mesenchyme, ie. the bone develops within the soft connective tissue. The mesenchymal cells proliferate and condense, concurrent with an increase in vascularity at these sites of condensed mesenchyme, osteoblasts differentiate and begin to produce bone matrix. (24) (Fig. 7)

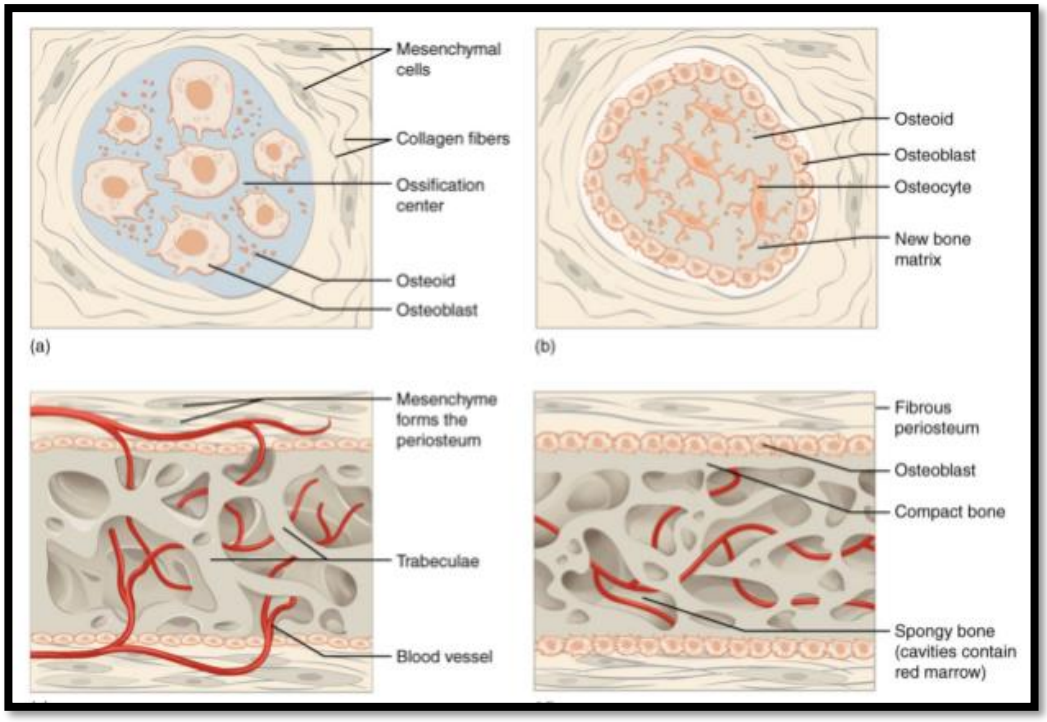


Figure. 7: Schematic image depicting events in Intramembranous bone formation.

Sutural Bone growth: Sutures play an important role in growing the face and skull. When two bones are separated—for example, the skull bones are forced apart by the growing brain—bone forms at the sutural margins, with successive waves of new bone cells differentiating from the cambium.

Development of the Primary ossification centre

The primary centre of ossification lies in the middle of the shaft, which undergoes following events:

- Formation of Periosteum – As vascularity improves, the perichondrium becomes the periosteum. Undifferentiated osteoprogenitor cells on the periosteum later become osteoblasts.
- Formation of Bone collar – The Osteoblasts secrete osteoid against the shaft of the cartilage model(appositional growth). These acts as scaffold support for the new bone.
- Calcification of Matrix – Chondrocytes at the primary centre of ossification undergo hyperplasia. Alkaline phosphatase secreted from the chondrocytes is essential for mineral deposition and calcification of the matrix. Following this , hypertrophic chondrocytes undergo apoptosis and creates cavities within the bone.
- Invasion of periosteal bud – The hypertrophic chondrocytes secrete VDGFs(vascular endothelial cell growth factor) that includes the sprouting of blood vessels from the perichondrium. Sprouting blood vessels from the periosteal bud and invade the formed cavity carrying the hemopoietic cells and osteoprogenitor cells. The hemopoetic cells form the bone marrow. Osteoclasts formed from macrophages, breakdown spongy bone to form the medullary cavity.
- Fomation of Trabeculae – Newly formed osteoblasts within the cavity secrete osteoid, which lays down over the calcified matrix acting as scaffold for bone trabecula.

Development of secondary ossification centre

At birth a secondary ossification centre appears in each epiphysis of the long bones. Periosteal buds carry mesenchyme and blood vessels in which the primary ossification centre forms. The cartilage between the primary and secondary ossification centre is called the epiphyseal plate, and it forms new cartilage, which is replaced by bone, resulting in an increase in length of the bone. Growth continues until the cartilage in the plate is replaced by bone or about 21 years of age. The point of union of the primary and secondary ossification centres is called the epiphyseal line.

Formation of articular cartilage and epiphyseal plate:

The cartilaginous extremity (where an epiphysis usually forms) grows by appositional and interstitial mechanisms. When the whole bone is reaching maturity, epiphyseal and metaphyseal ossification gradually encroaches upon this growth plate and final bony fusion occurs with cessation of growth.

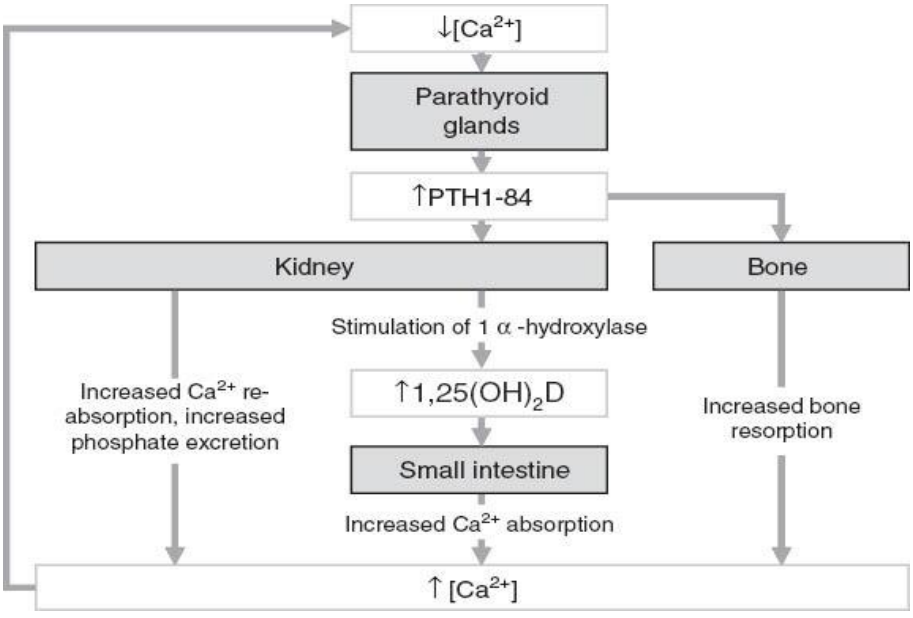
FACTORS REGULATING BONE ACTIVITY

The most important regulating hormones with respect to bone health are:

A. Calcium-Regulating Hormones

Three **calcium-regulating hormones** play an important role, they are:

1) **Parathyroid hormone**, which maintains the level of calcium and stimulates both resorption and formation of bone. It acts on three important sites – bone, intestine and kidney which maintain strict control of serum calcium levels. Maintenance of free calcium concentration of the ECF is the basic function of PTH. PTH acts on the kidney to increase calcium reabsorption and stimulate renal production of 1,25(OH)2 Vitamin D to increase intestinal absorption of calcium and maintain the ECF concentration of calcium.(25)



2**) Calcitriol**, the hormone which stimulates the intestines to absorb enough calcium and phosphorus.

3) **Calcitonin**, which inhibits bone breakdown and protect against excessively high levels of calcium in the blood. Calcitonin in a protein hormone secreted by parafollicular cells of thyroid. Ionized calcium regulates calcitonin secretion, increase in ionized calcium produces an increase in calcitonin secretion , which inhibits osteoclasts and therefore bone resorption in pharmacologic doses.

B. Sex Hormones

Sex hormones are also extremely important in regulating the growth of the skeleton and maintaining the mass and strength of bone. The female hormone estrogen and the male hormone testosterone both have effects on bone in men and women. (26) The high concentration that occurs at the end of puberty stops further growth in height by closing the cartilage plates at the ends of long bone. Estrogen acts on both osteoclasts and osteoblasts to inhibit bone breakdown at all stages in life. The marked decrease in estrogen at menopause is associated with rapid bone loss.

Testosterone is important for skeletal growth both because of its direct effects on bone and its ability to stimulate muscle growth, which puts greater stress on the bone and thus increases bone formation.

C. Other Important Hormones: Growth hormone from the pituitary gland is an important regulator of skeletal growth. It acts by stimulating the production of

another hormone called **insulin-like growth factor-1**. Decreased production of growth hormone and IGF-1 with age may be responsible for the inability of older individuals to form bone rapidly or to replace bone lost by resorption.

Thyroid hormones increase the rates of both bone formation and resorption. Excessive amounts of thyroid hormone can cause too much bone breakdown and weaken the skeleton.(27)

Cortisol is a critical regulator of metabolism and is important to the body's ability to respond to stress and injury. It has complex effects on the skeleton. Small amounts are necessary for normal bone development, but large amounts block bone growth. Synthetic forms of cortisol, called glucocorticoids can cause bone loss due to both decreased bone formation and to increased bone breakdown, both of which lead to a high risk of fracture(28).

BONE REMODELLING

Throughout life, bones change in size, shape, and position. Two processes guide these change — Modeling and Remodeling.(29)

The process by which the overall size and shape of bones is established is referred to as ***bone modeling*** and extends from embryonic bone development to the preadult period of human growth. During this phase, bone is being formed rapidly, primarily on the periosteal surface. Simultaneously, bone is being destroyed along the endosteal surface. Modelling is a process by which bone adapts overall change in shape in response to mechanical forces it encounters during development.

During adult life, the skeleton undergoes a continual process of repair and renewal. **Bone remodeling** is the process by which bone is renewed to maintain bone strength and mineral homeostasis. It is the primary mechanism whereby bone is renewed and adapts to changes in load bearing. Remodeling involves continuous removal of discrete packets of old bone, replacement of these packets with newly synthesized proteinaceous matrix, and subsequent mineralization of the matrix to form new bone. The remodeling process resorbs old bone and forms new bone to prevent accumulation of bone microdamage. It is a useful process for decreasing skeleton size in the event of immobilization and for repairing the micro damage before they become clinically apparent. Remodeling begins before birth and continues until death. The bone remodeling unit is composed of a tightly coupled group of

osteoclasts and osteoblasts that sequentially carry out resorption of old bone and formation of new bone.(7) (Fig. 8)

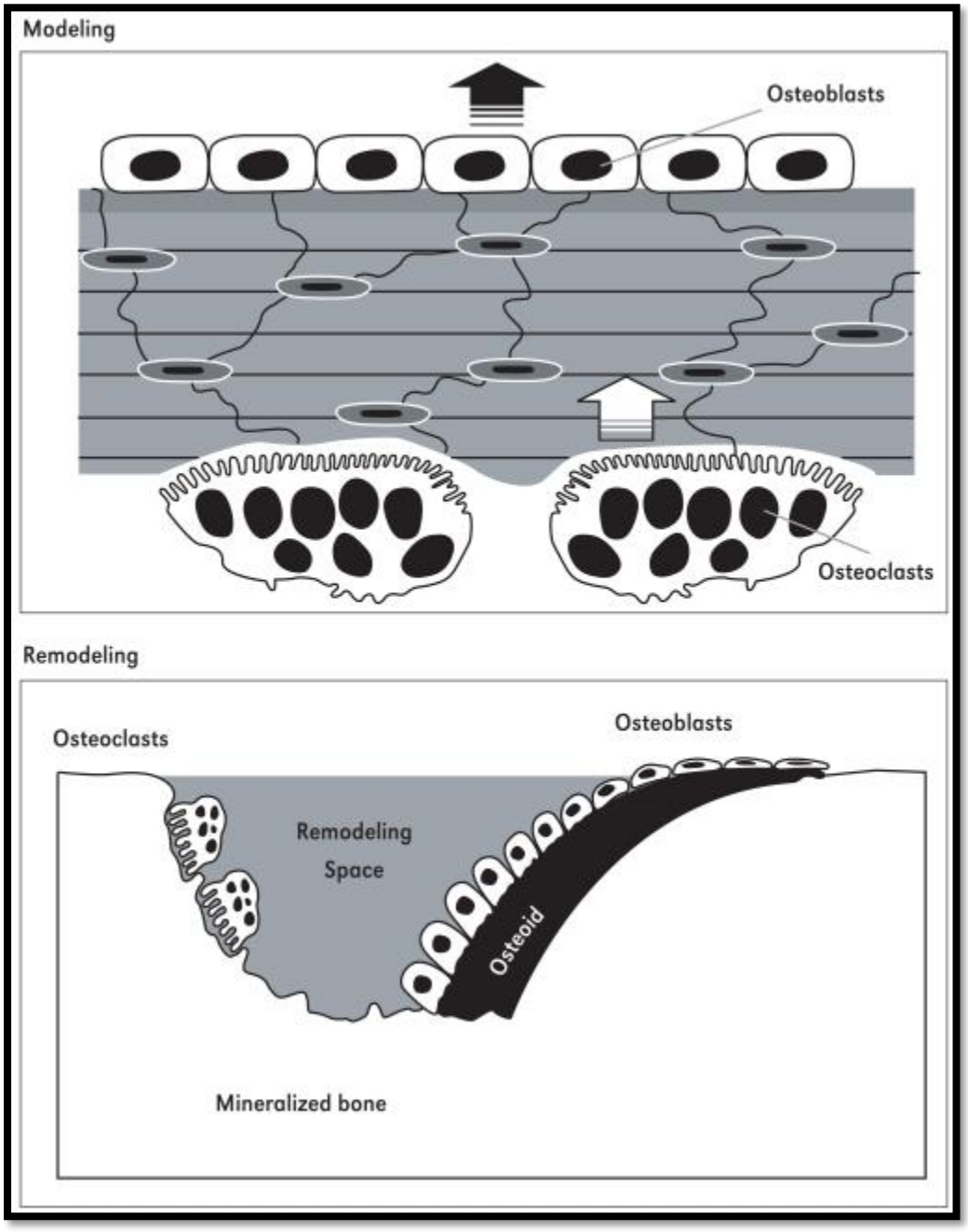


Figure.8 : Modelling and remodelling.

Osteocytes play an important role in cell signaling, regulating osteoblast and osteoclast function and sensing mechanical loading. (30) The net amount of bone formed is termed bone balance. A negative bone balance occurs at menopause, immobilized patients and in astronauts in a microgravity environment. Remodeling sites mostly develop in a random manner but are also targeted to areas that require repair.

Types of Remodeling

- Targeted / Stochastic remodeling – Targeted remodeling is responsible for the repair of micro damage. It is supposed to be the most important pathogenetic factor for increased bone fragility in osteoporosis. (31) Increase / accumulation of micro damages leads to structural failures.
- Non targeted / non stochastic remodeling helps in maintaining the plasma calcium homeostasis.

SEQUENTIAL PHASES OF REMODELING

QUIESCENCE

It is a period of relative inactivity. After the tunneling and refilling , some osteoblasts become osteocytes, remain in bone and sense mechanical stresses on bone. Remaining osteoblasts become lining cells.

ACTIVATION

It occurs when bone experiences micro damage or mechanical stress or randomly. A bone morphological unit (BMU) orginates and travels along the bone surface. This is followed by retraction of bone lining cells(osteoblasts on surface) and digestion of the endosteal membrane membrane by collagenase enzymes. This completes the first step towards activation. Activation of monocytes-macrophage system and osteoclast precursor cells from the circulation, results in interaction of osteoclast and osteblast precursors. This leads to the differentiation , migration and fusion of the multinucleated osteoclasts which attach to the mineralized bone surface and initiate resorption.(32)

RESORPTION

Newly differentiated osteoclasts are activated and begin resorption. Minerals are dissolved and the matrx is digested by lysosmal enzymes and hydrogen ions, particularly cathepsin K, which can degrade all the components of bone matrix, including collagen, at low pH. Osteoclastic resorption produces irregular cavities called Howship's lacunae and cylindrical Haversian canals in trabecular bone and corical bone respectively(33). It takes 2-4 weeks for resorption during each remodeling cycle(34).

REVERSAL

It is the transition from osteoclastic to osteoblastic activity. Cavities fromed at the end of resorption contain monocytes. Osteocytes released from the bone matrix recruited to begin new bone formation. The proposed coupling signal candidates lnking the end of resorption

to beginning of formation are IGF-1,2 bone morphogenic proteins and fibroblast growth factor.

FORMATION

It is the transition from osteoclastic to osteoblastic activity. Osteoclasts are replaced by cells of the osteoblast lineage. The growth factors are liberated from the matrix which acts as chemotactics and stimulate their proliferation. The preosteoblasts secrete cement like substance upon which the new tissue is attached and express bone morphogenic proteins (BMP), which is responsible for differentiation. Differentiated osteoblasts synthesize the osteoid matrix which fills the cavity perforated areas. Some osteoblasts continue synthesizing bone until they transform to quiescent lining cells that cover the new bone surface and connect with the osteocytes in the bone matrix through canalicular network.

MINERALISATION

Bone tissue is composed of a mineral portion in an organic matrix constituted by type 1 collagen fibrils. The degree of mineralization of bone and the characteristics of the mineral deposited (apatite crystals) are major determinants of bone strength. Mineralisation involves not only the initial deposition of mineral in oganic matrix but also its maturation until the upper mineral density in a given volume of matrix is reached. Mineralisation is a multistep process during bone remodeling. Newly formed organic matrix deposited by

osteoblasts begin to mineralize 5-10 days after deposition by secondary nucleation i.e the crystals act as nucleation sites for the new ones. This first step leads to a mineral content corresponding to 50-70% of the maximal value. After a few days , or weeks, the speed of mineralization decreases substantially and secondary mineralization begins. This latter process corresponds to gradual increase in crystal size, number and perfection, occurring on the year-scale until the maximum (mean degree of bone mineralization) DMB is reached. Independent of bone mass and its distribution in space, the mineralization and the quantity of the mineral play a crucial role in the elastic, plastic and viscoelastic properties defining the mechanical behavior of bones.

Mineral deposition happens at multiple discrete sites of the collagen fibres. This process also is regulated by the osteoclasts. After mineral maturation, once the cavity is full, the mineral crystals pack together , increasing the density of the new bone. The cycle continues and quiescent phase begins again. One cycle of remodeling equalizes amount of bone formation and bone resorption.

OSTEOPOROSIS

Osteoporosis is one of the most common bone disease. It is a skeletal disorder characterized by compromised bone strength, predisposing to an increased risk of fracture.

Factors important in determining bone strength

a) composition of the mineral and matrix,

b) fine structure of the trabecular bone,

c) porosity of the cortical bone, and

d) presence of micro-fractures and other forms of damage in bone.

Changes in the micro-architecture of trabecular bone are particularly important since the most common fractures in osteoporosis occur at the spine, wrist, and hip, and sites where trabecular bone predominates.

The structure of normal trabecular bone consists of well-connected plates or broad bands that provide great strength. In individuals with osteoporosis these bands are disrupted and often become thin and weakened. Some of these rods are no longer connected to other pieces of bone, meaning that they no longer contribute to bone strength.(29) (Fig. 9)

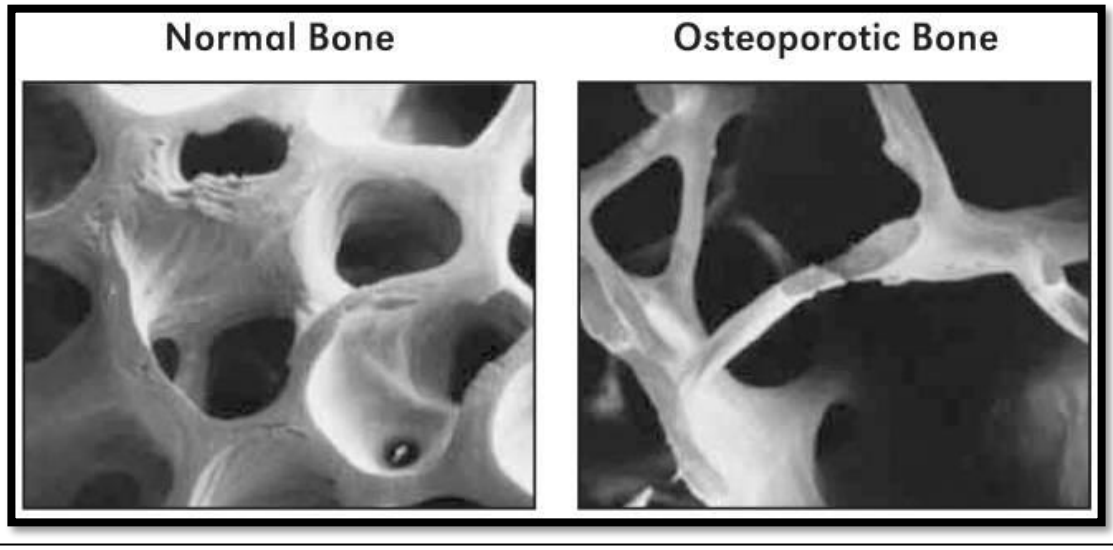


Figure.9: scanning electron micrograph image depicting normal and osteoporotic bone.

Defective repair of micro damage results from physiologic laoding occurring in normal daily life. These features are also observed in age related bone loss and increased bone remodeling rates greater than those found in normal premenopausal women.

BONE DENSITY

Peak bone mass – It determines 50-70% of bone strength. Bone mass reaches its peak at about 20 years of age in males and 18 years in females. Peak bone mass determines long term fracture risk. Paediatric population are at high risk for fractures as they have not attained their peak bone mass.

BONE QUALITY

Micro architecture

Resistance to fracture to fracture is very essential. It depends upon the amunt, size, shape and connectivity of trabecular bone and cortical bone tissue. There is decrease in size and number of trabeculae in osteoporosis. The stronger plate like morphology that is seen in non osteoporotic bone is replaced by thinner and rod like trabeculae. The primary cause of these changes in micro architecture is due to excessive bone remodeling in osteoporotics.

Turnover

Higher bone turnover influences bone strength by affecting mineralization. The probability of a cortical or trabecular bone structural unit (BSU) to be resorbed before the completion

of its secondary mineralization increases when bone turnover is high. This leads to greater proportion of younger and sub maximally mineralized bone. This increases the proportion of immature crystals with a low crystallinity.(35).

Microdamage

Micro damage occurs due to repeated sub maximal loading. It can disrupt the communication of osteocytes and can transect lamellae and canaliculi. This process can trigger osteocyte apoptosis, which signals osteoclast precursors to differentiate into osteoclasts that target the microdamage for removal and repair by osteoblasts. Clinically apparent fractures are formed when these small cracks coalesce, forming larger cracks left unpaired. (36) Once a trabecular surface is eliminated , subsequent formation does not happen at that location. Excess of weakened loci in trabeculae and an increase in micro damage outpaces the ability to repair. Micro damage increases with age which can accumulate and result in structural failure (Fig 10).

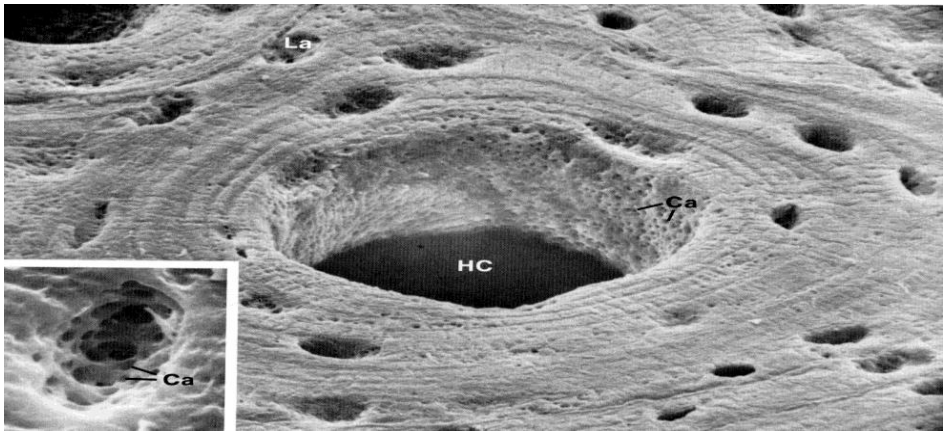
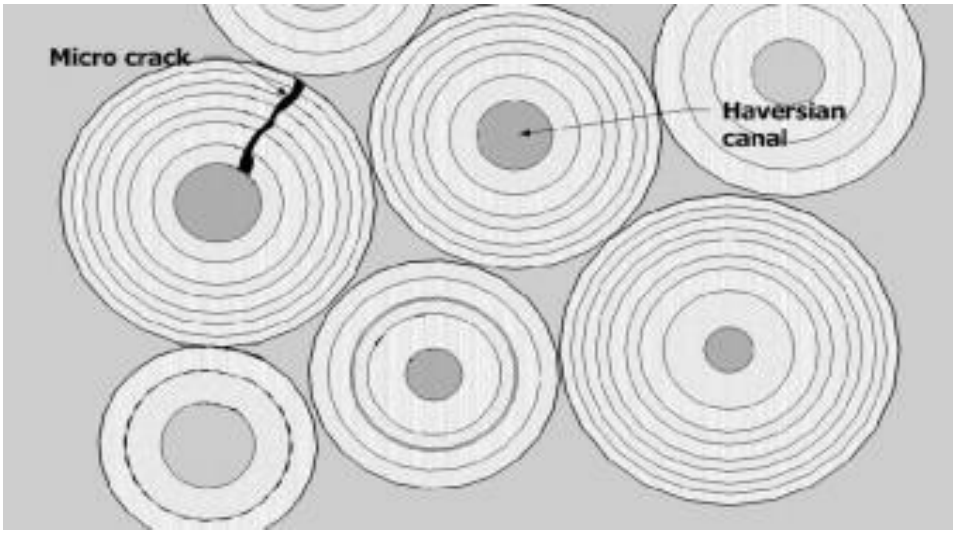


Figure 10 :Haversian canal with lamellar bone and microcrack



Mineralisation

Bone remodeling activity acts as a regulator of the degree of mineralization and of the distribution of mineral at the tissue level, directly impacting bone mechanical properties. Reduced bone turnover activity provide osteons and bone trabecular packets (BSU) with more time to complete their secondary mineralization before being resorbed in a further remodeling cycle. Therefore a grater proportion of tissue is maximally mineralized not only increasing the mean tissue mineral content but also narrowing its distribution.

PATHOPHYSIOLGY OF BONE LOSS IN SCI

1. LOCAL FACTORS
    - Mechanical unloading.
    - Reduced mechanical signals

2. DENERVATION
    - Autonomic disregulation.
    - Neuropeptide expression.

3. HORMONAL DYNAMICS
    - Suppression of PTH – Vitamin D axis following hypercalciuria in the acute phase of spinal cord injury.
    - Vitamin D levels and low sun exposure following injury.
    - Increased cortisol levels due to stress.
    - Steroids in the course of treatment.
    - Inhibitory effect of spinal cord injury on the synthesis and secretion of sex steroids contributes to the pathogenesis of SCI induced osteoporosis.

Multiple factors are responsible for skeletal changes following SCI. Immobilisation and mechanical unloading are the main factors during the acute phase. Bone loss is

significantly higher in SCI . Mechanical loading play a significant role in maintaining the strength by mechanosensation mediated through osteocytes, which creates perturbation of cell membrane and bone fluid leading to shear stress , which contribute to mechanosensation and mechanotransduction. (37)

OSTEOPOROSIS IN SPINAL CORD INJURY

Osteoporosis is an inevitable complication found in almost every individual following spinal cord injury. Osteoporosis is defined by the World Health Organizaion as a condition characterized by low bone mass and micro architectural deterioration of bone tissue leading on to increase in the bone fragility and predisposing to fracture (38). In SCI these fractures might be asymptomatic but may lead to many complications. Thus fracture prevention and managing of neurological osteoporosis remains a challenge. Immobilisation post SCI and neurological lesion induces early and severe bone loss especially among young adults (39).

Demineralisation occurs exclusively in the sublesional areas and predominantly in the weight bearing skeletal sites such as distal femur and proximal tibia which are trabecular rich sites during the first months of post injury. The diaphyseal areas of the femur and tibia are relatively spared as they are cortical rich sites (40) . By dual energy Xray aborptiometry (DEXA) technique , Wilmet et al reported a decrease in bone mineral content (BMC). There has been a reduction in BMC about 4% per month in areas rich in trabecular bone and 2% per month in areas rich in cortical bone (41). This clear dissociation of bone mineral content (BMC) loss is studied and confirmed by quantitative computed tomography (pQCT) technique (42). Demineralisation of lumbar spine, pelvis, and lower limbs are independent of the neurological level.

Demineralization occurs exclusively in the sublesional areas and predominantly in weight-bearing skeletal sites such as the distal femur and proximal tibia, during the first 24 months postinjury. Both of them are trabecular-rich sites (43). Bone mass loss in epiphysis is related to bone mineral density decrease and reduced cortical wall thickness in the shaft is by the process of endosteal resorption (42). There is no reduction in BMD at the lumbar spine which is mainly composed of trabecular bone, whatever be the level of lesion or duration of injury. This is due to the continuous body weight – bearing during sitting as well as wheelchair using.

The main factors that causes sublesional osteoporosis is due to decrease in mechanical forces applied to the bone, lesion induced blood circulation abnormalities that affect bone cell differentiation and hormonal deficiencies (40). Histomorphometric data suggests that the principal cause for bone loss is the increase in bone resorption by an augmentation in eroded surfaces and the number of osteoclasts. Study of bone biochemical markers showed that bone resorption continuously increases from the first weeks post injury and peaks from 10 and 16 weeks. Here the values reach upto 10 times the upper limits of normal. After one year the markers of bone resorption which is hydroxyproline and deoxyproline remains elevated. Meanwhile the bone formation markers show only a minor rise. It is this imbalance between bone formation and bone resortion which is responsible for bone loss after SCI (31,39,40).

FRACTURES IN SCI

Low impact fractures are seen in individuals with SCI. It has been reported to occur during occasions that would not normally cause fracture, such as a transfers from bed to chair, or being turned in bed (44). The lower extremities are mainly affected by fractures, and they are typically located in the diaphyseal or distal femur and in the proximal lower leg (38). During the initial months of post injury, demineralization occurs exclusively in the sublesional areas, which are predominantly in the weight bearing skeletal sites such as the distal femur and proximal tibia, which are trabecular-rich sites. Where as the diaphyseal areas of the femur and the tibia, which are cortical-rich sites, are relatively spared. In SCI population, the fracture rate is reported to be from 1% to 21 of patients (6). Prevalence of fractures has been reported to increase with time post-SCI, from 1% in the first 12 months to 4.6% in individuals more than 20 years post injury . Bone demineralization predominantly occurs at the distal femur or proximal tibia, hence could explain that these are the most common areas of fracture (1,45,46). SCI in women have been reported to have a 1.6 times higher risk of long-bone fractures as compared with SCI in men. This is due to increased bone loss in women than in men. Neurological level in SCI also contributes to the fracture rates as patients with lumbar spinal injury have 2.4 times more fractures than those with cervical injury (47). Carbone et al (48) have observed 54% post-fracture complications in SCI patients with lower-extremity fractures. Main complications seen after fractures are pseudoarthirits, joint stiffness, internal or external rotation of limb, complex regional pain syndrome, limb discrepancy, skin infections, infections,

pressure ulcers, neuropathic pain, autonomic dyreflexia and spasms of lower limbs. All these fractures are asymptomatic and induce complications and hence leads to morbidity.

CIRCUMSTANCES OF FRACTURE IN SCI

1. Traumas which are well identified: They usually are caused by direct involuntary impact (eg, falls from wheelchair or bed and/or road traffic accidents).

2. Traumas that are unidentified at first, but incriminated later on: They involve extreme stretching movements, bad posture during transfers . Morse et al (49) reported that transfers and wheelchair techniques contributed to 20% of fractures requiring hospital admission . In most cases its due to stretching exercises or abnormal postures which were aimed at improving joint range of movement and comfort. Its also seen in management of spasticty were passive exercises are given.

3. No reported traumas that led to delayed fracture discovery: They are symptoms such as swelling, wrongly positioned lower limb, any limb length discripency which guides the physician towards a diagnosis of fracture.

Dauty et al (50) reported that the duration of the initial immobilization of spinal cord injury patients is the main factor that significantly affects BMD at the trochanteric area. Therefore early therapeutic standing of the body could contribute to reducing the initial bone demineralization. The maintenance of normal axial bone-loading by passive standing

by standing frame or tilt table or by various walking aids systems has been promoted as a therapy to reduce calcium losses and subsequently retard or reverse SCI-associated osteoporosis (51)

MECHANOSTAT THEORY

During remodeling, alignment of new bone is along the dominant local loading direction, suggesting local regulation of bone formation by mechanical stimulus. Mechanical loading is important for bone formation and resorption which improves bone mass, structure and strength. The high mechanical stresses (or strains) induces an inherent biological control system that directs bone formation. This system, is called the '**mechanostat**'.

Mechanostats are resident cells within bone tissue that detect and respond to mechanical loads. Osteocytes are the mechanosensory cells of bone. Osteocytes situated in the bone matrix respond to mechanical load signals, and the gap junction of the long processes of osteocytes transmits mechanical load signals via intracellular signal transmitters (Ca2+, IP3, cAMP, cGMP) and extracellular signal transmitters (PGE2, PGI2, IGF-1, IGF-2 and TGF-). This induces bone formation by osteoblasts and inhibition of bone resorption by osteoclasts. The effect of mechanical loading on bone tissue is an increase in bone formation on the periosteal bone surfaces, thus improving bone strength and reducing bone turnover and bone porosity. Unloading induces osteoblastic cell suppression and osteoclastic cell activation to lead to bone loss. SCI causes unloading and decreased movement of the lower limb joints and causes substantial muscle atrophy . Unloading may play an important role in the development of osteoporosis after SCI. This raises the question that whether functional exercise can prevent bone loss after SCI as unloading can be reversed by ambulation.(52)

FUNCTIONAL WALKING IN SPINAL CORD INJURY

A recent case series reported increases in lean mass, muscle area and bone mineral density in individuals with acute SCI as a result of early weight bearing via body weight–supported treadmill training (53). A cross-sectional study demonstrated that persons with complete SCI who had been made to stand in the acute phase post injury, either with long leg braces, a standing frame, or a standing wheelchair, had better preserved BMD at the femoral shaft and/or proximal femur than those who had not(51). Rehabilitation Medicine plays a vital role in preventing complications and helping the patients to have the same life expectancy as normal people. One of the major interventions include functional ambulation using orthosis. Functional ambulation is the ability to walk with the aid of appropriate assistive devices (orthosis), safely and sufficiently to carry out mobility related activities of daily living (54).

Ambulation is graded in four categories (5)

1) Community ambulators- defined as those who were able to get themselves out of a wheelchair or bed and walk for reasonable distances both in and out of the house unassisted. They may use braces and or crutches and may use a wheelchair for long distances.

2) Household ambulators- those who require assistance in getting out of bed or wheel chair , were able to walk within the house with relative independence , but were unable to ambulate outside for any significant distance and used a wheelchair.
3) Exercise ambulators- required significant assistance in order to ambulate.
4) Non ambulators only used a wheelchair.
5) Both the community and household ambulators were considered to be functional ambulators.(5)

MATERIALS AND METHODS

MATERIAL AND METHODS

This is a Cohort study to find out the incidence of lower limb fractures in rehabilitated chronic traumatic spinal cord injury patients of T10 neurological level and below. This study was conducted in the Department of Physical Medicine and Rehabilitation. Seventy patients were enrolled for the study for a period of one year (2017 – 2018). Patients who have been rehabilitated from the department of PMR, CMC Vellore who fits into the inclusion criteria were recruited. The patients were either selected from Rehab mela or through home visits/ regional mela. Rehab mela is a yearly follow up of spinal cord injury rehabilitated patients from the department of PMR, CMC Vellore. It is conducted every third week of February. Regional level mela is a rehab mela which is conducted by spinal cord injury rehabilitated patients in the community. Home visits are done among patients who have been rehabilitated from the Department of PMR,CMC Vellore.

•A detailed interview and data collection was done with the help of a semi structured questionnaire focusing on history of fractures after rehabilitation. A phone interview was also done towards the end of the study to know the secondary outcomes.

• Clinical examination was conducted to measure limb length discrepancies and abnormal range of joint motion.

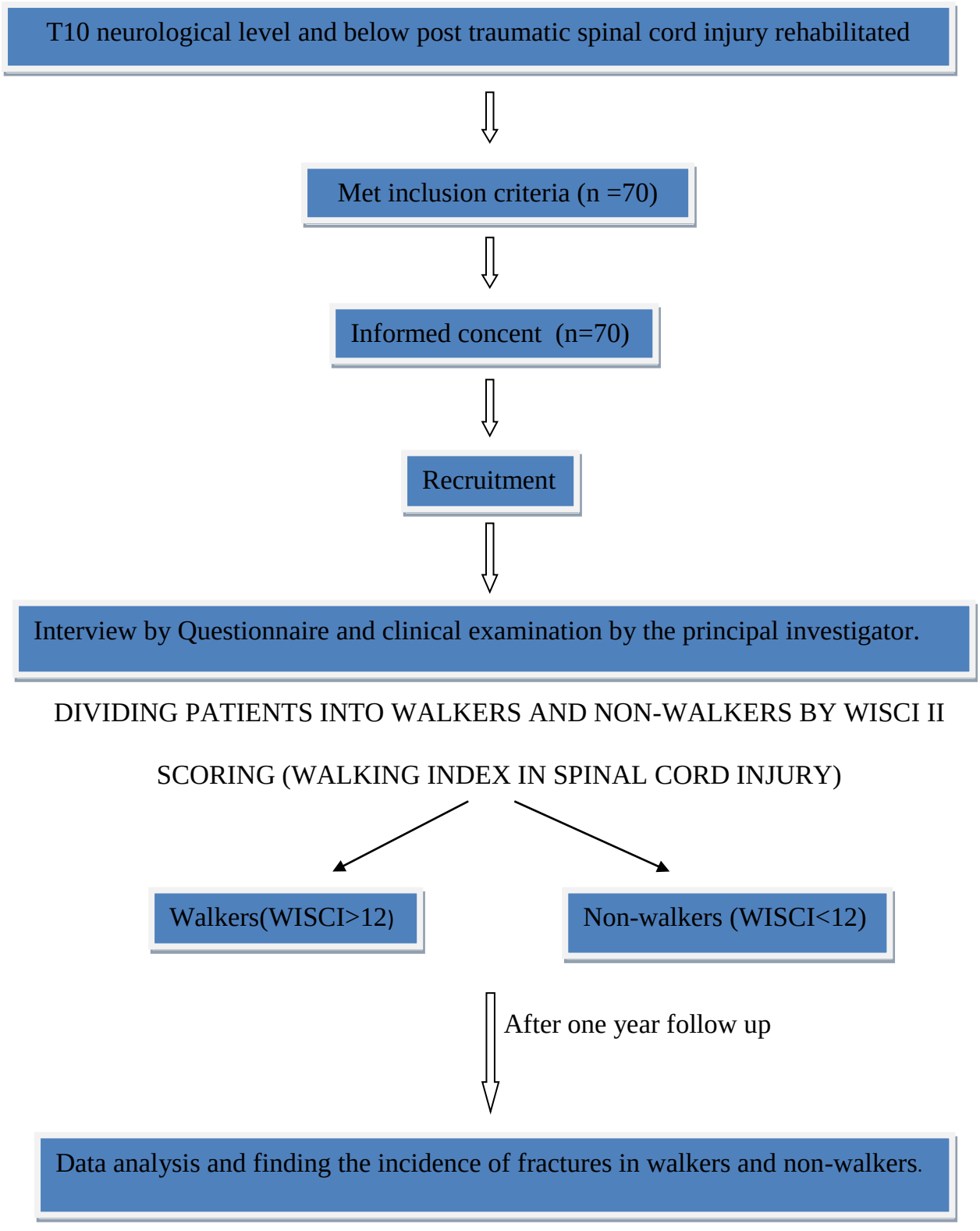
• Walking distance of functional ambulators were measured in meters using the standard walking ramp in rehab institute or using a fitness band tracker at their home.

• Participants were divided into walkers and non-walkers by using a Walking Index in Spinal Cord Injury scoring system(WISCI score). Score of 12 or more is considered as walkers and less than 12 will be non-walkers. (55)

• One year later the recruited patients (walkers v/s non walkers) were followed up during rehab mela and from home visits/regional mela. Same interview and clinical examination was done to find out any fractures in the participants.

• The data is statistically analyzed to calculate the incidence of fractures of the patients included in the study. Following which the incidence of lower limb fractures in walkers versus non walkers were compared.

DIAGRAMMATIC ALGORITHM OF THE STUDY



PARTICIPANTS

Inclusion criteria:

1) Neurological level T10 and below.

2) Traumatic spinal cord injury .

3) One year post spinal cord injury rehabilitation.

4) Age between 18 and 60.

5) Only long bone fractures of lower limb.

6) Patients who are willing to participate and give a valid and informed consent

Exclusion criteria

1) T9 neurological level and above

2) Any lower limb fractures before spinal cord injury or rehabilitation.

3) Non traumatic spinal cord injuries.

4) Pregnant ladies

5) Age below 18 and above 60.

STATISTICAL METHODS

Firstly, to describe the sample characteristics, we used descriptive statistics. Therefore either means with standard deviation for continuous variables and numbers with their percentages were used for the categorical variables. The 1-year outcome variable were not skewed in their distribution and so parametric analysis were used. Secondly, in the bivariate analysis, to compare between the group who were walkers and those who did not walk were compared with independent students t- test for continuous variables and Chi-square test for categorical variables. Thirdly those variables that came in multivariate logistics regression analysis. The regression analysis was considered as the 1- year outcomes which were all dichotomous in nature. In all the univariate logistic regression analysis the constant was included. Since the age of the participant, the type of mobility and the orthosis used were considered to have effect on the one year outcome independently, they were considered as confounders and were controlled in the multiple multivariate logistic regression analysis. Finally a full risk factor model was built based on the variables that were significant in the univariate or multivariate analysis. All tests were 2- tailed and a p value of <0.05 was considered statistically significant. The data were entered in the epidata and analysis were done using SPSS (version) .

RESULTS

The results section is discussed under the headings of Sample characteristics, the difference in the primary and secondary outcomes between groups.

Table 1: Sample demographic characteristics:

Variable	N=70	Percentage
Age [mean(SD)]	41.37(10.25) years	
Gender		
Male	66	94.29
Female	04	5.71

The sample demographic characteristics revealed that majority of the participants were male and their mean (SD) age range from 22- 59 years as documented in table 1.

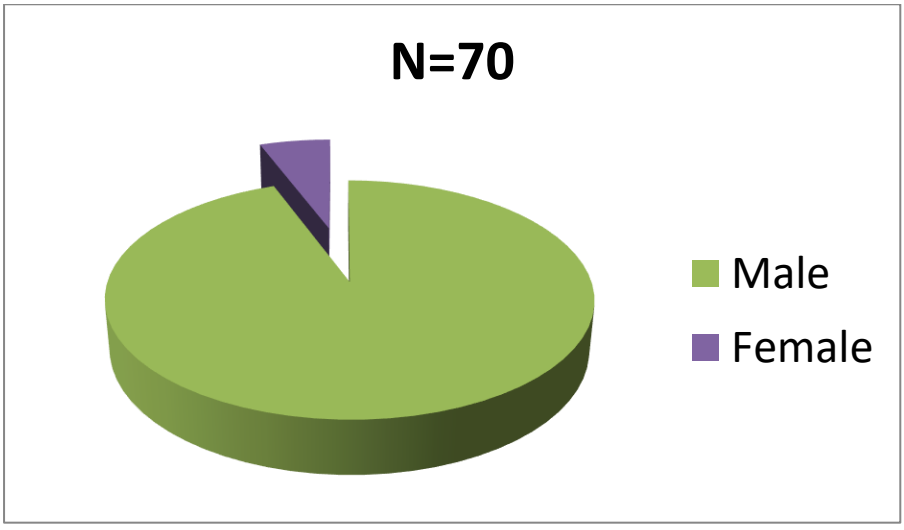
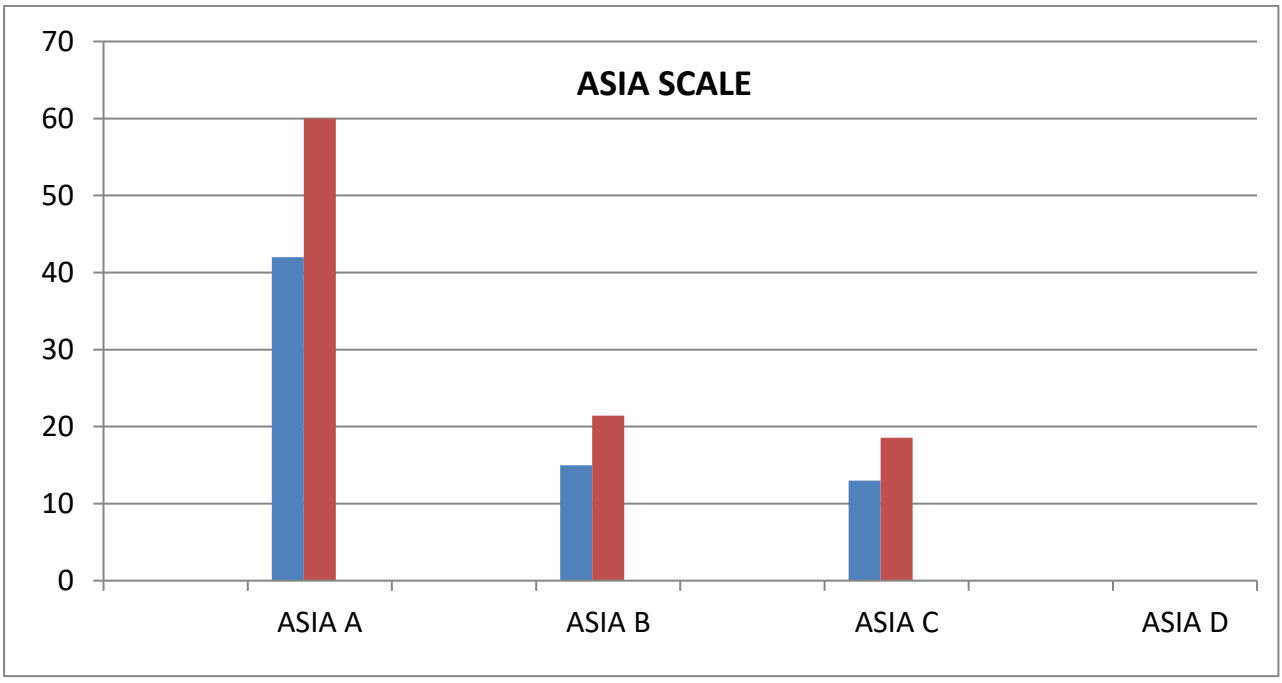
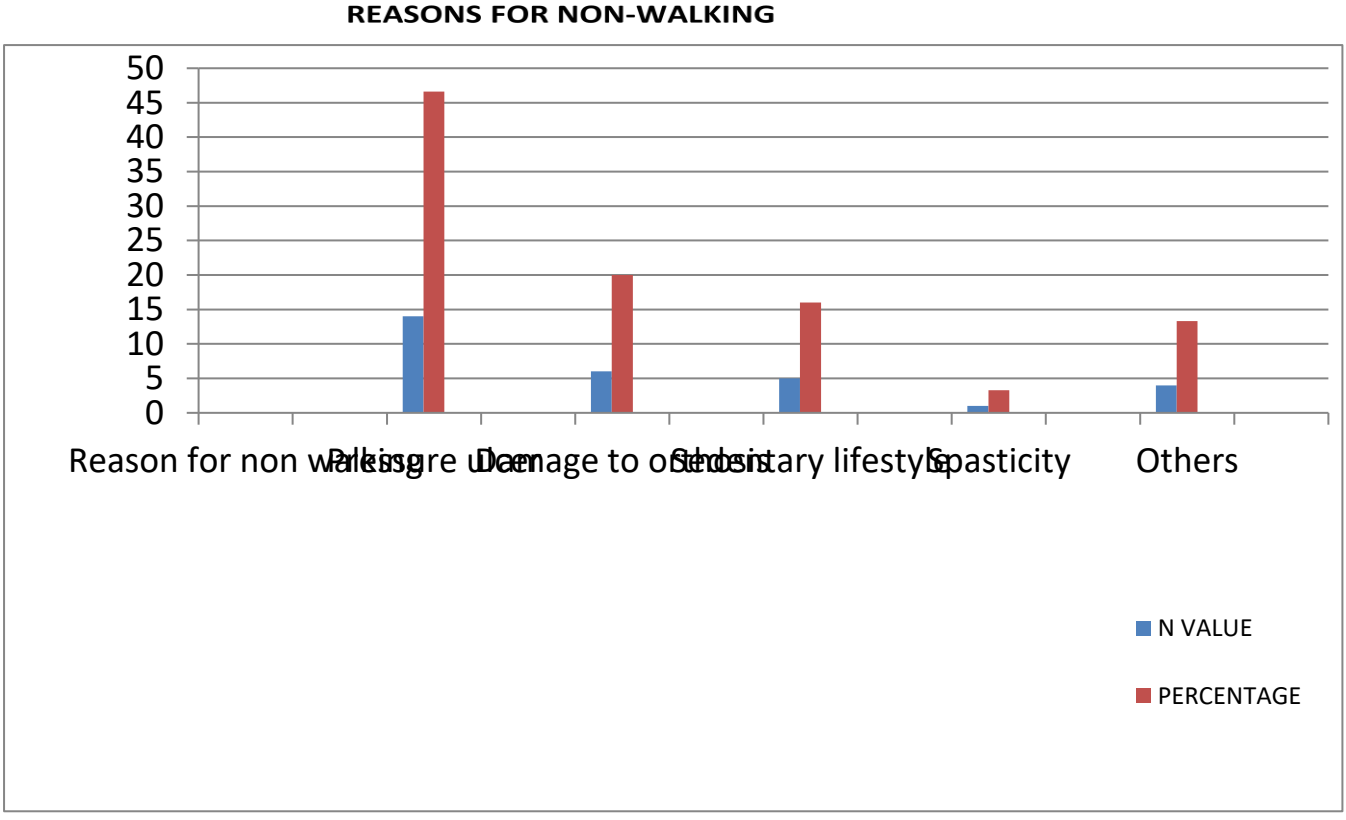


Table 2: Sample disability characteristics.

Variable	N = 70	Percentage
ASIA Scale		
ASIA A	42	60
ASIA B	15	21.43
ASIA C	13	18.57
Reason for non walking	N = 30	
Pressure ulcer	14	46.6
Damage to orthosis	6	20
Sedentary lifestyle	5	16
Spasticity	1	3.3
Others	4	13.3
Type of Ambulation	N = 40	
Community ambulators	34	85
Household ambulators	3	7.5
Exercise ambulators	3	7.5
Orthosis and Aids for walking	N=40	
Bilateral Elbow Crutch and KAFO	29	72.5
Bilateral Elbow Crutch and AFO	5	12.5
Walker and KAFO	2	5
Bilateral Elbow Crutch	4	10

*KAFO – Knee ankle foot orthosis, AFO – Ankle foot orthosis





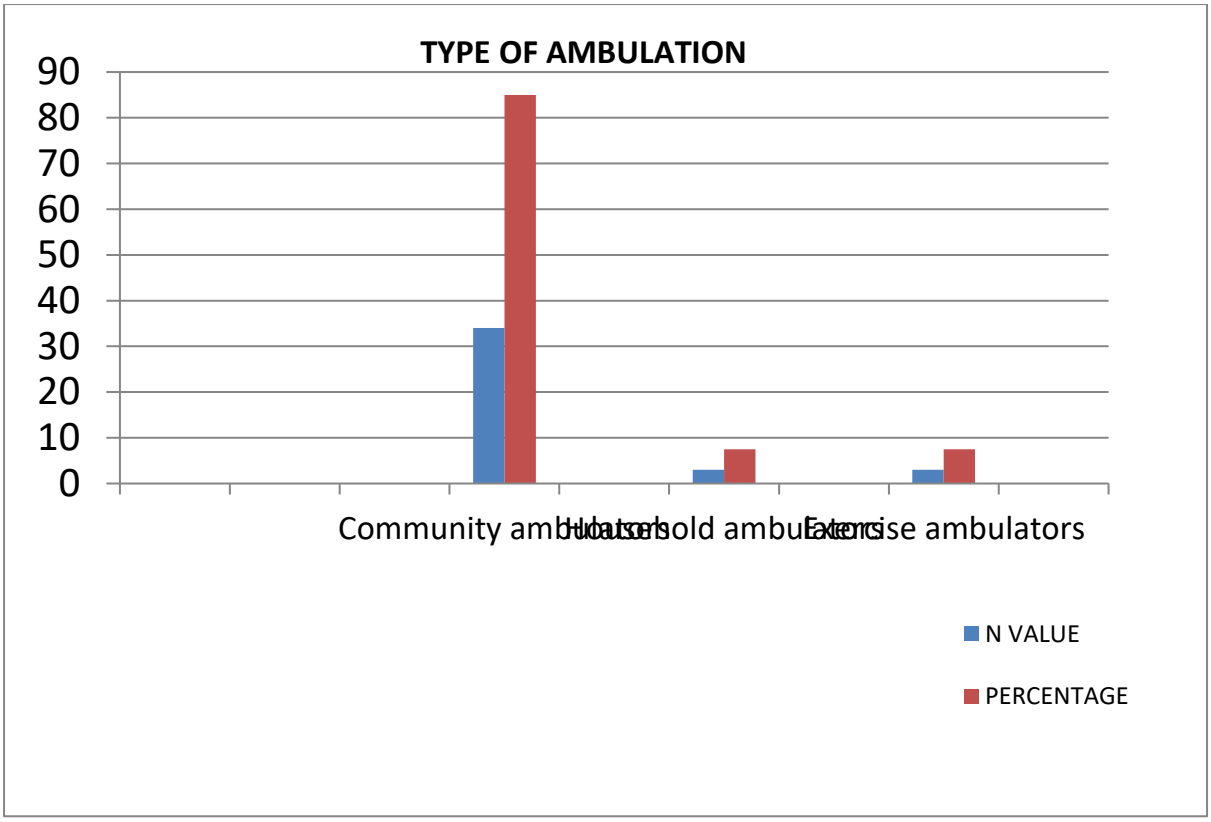


Table 2 describes the various disability characteristics . Majority of the participants had ASIA A severity of spinal cord injury. Also, among the non walkers about half had pressure ulcers and another quarter of them had damage to the orthosis. Sedentary lifestyle and other family related and society related numbers were notted. Among the one who were walkers, significant majority were able to walk in the community and only under 10% each were walking only within the home and were capable of doing their daily exercises. However among those who were walking, again a significant majority were walking with bilateral elbow crutch and knee ankle foot orthosis (KAFO).

Table 3: Sample 1-year outcome characteristics.

Variable	N=70	Percentage
Primary outcome		
Fracture	0	0
Secondary outcome		
History of fall		
No	59	84.28
Yes	11	15.71
Number of falls		
No fall	58	82.85
Low	2	2.85
High	10	14.28
Pressure Ulcer		
No	55	78.57
Yes	15	21.42
Vocation		
No	33	47.14
Yes	47	67.14

Table 3 which records the one year outcome of the entire sample, none of them has had fracture. It also shows majority did not have a fall but the frequency of fall was higher among those who fell during the one year study duration. Pressure ulcer was seen in a quarter of the sample and majority were actively participating in some kind of vocation.

THE DIFFERENCE IN VARIOUS CHARACTERISICS BETWEEN THE NON WALKER AND WALKER GROUPS

Table 4: The demographic characteristics between non walkers and walkers group.

Variable	**Non Walker N=30**	**Walker N=40**	**Chi – Square test χ^2/t**	**P value**
Age	46.23(10.06)	37.73(8.87)	3.74	0.001
Gender				
Male	28	38	0.08	0.76
Female	2	2		

As table 4 indicates the mean(SD) age of the participants in years, it was statistically and significantly different between the non walkers and walkers group. However equal number of males and females were present in both the groups and hence was not statistically significant.

ONE YEAR PRIMARY AND SECONDARY OUTCOME BETWEEN GROUPS

Table 5: The 1-year outcome between the groups

Variable	Non Walker	Walker	Chi - Square	P value
Primary outcome				
Fracture	0	0	-	-
Secondary outcomes				
History of fall				
No	22	37	4.75	0.02
Yes	8	3		
Number of falls				
No fall	22	36	3.62	0.16
Low	1	1		
High	7	3		
Pressure Ulcer				
No	16	39	19.86	0.00
Yes	14	1		
Vocation				
No	22	1	38.98	0.00
Yes	8	39		

Table 5 above documents that neither any participants from the walking or non walking group had sustained a fracture. Thus there were no primary outcome noted in either group.

Among the secondary outcomes, the history of fall, pressure ulcers and actively participating in a daily vocation was statistically significantly different between both the groups. The number of falls however were statistically not significant with both the groups.

Furthermore it is seen that number of participants who were non walkers had more falls, but the number of falls as mentioned were noted not significant in both groups. In addition pressure ulcers were statistically significantly more among those who were non walkers. On the other hand the participants who were walking had occupied themselves actively in a daily vocation which is statistically significant.

Table 6: Univariate regression analysis of all the variables.[a]

Variable	B(SE)	OR(95% CI)	P value
Vocation	4.67(1.09)	107.25(12.57, 914.79)	0.00
Ulcer	-3.530(1.07)	0.02(0.004, 0.24)	0.001
History of fall	-1.50(0.72)	0.22(0.05, 0.93)	0.03
Number of fall	-0.84(1.57)	0.42(0.02, 9.36)	0.59

[a]=All regression models had constant included in the analysis.

In the univariate logistic regression analysis, when we explore the risk associated with each of the variable that was significant in the bivariate analysis, we found that the history of fall, the presence of pressure ulcers and actively participating in a vocation was statistically

significantly observed in the different groups. Non walkers were statistically significantly at risk of not being occupied in a daily vocation. The risk of not being in a daily vocation was 107 times more in a person who is a non walker compared to a walker. The mobility was statistically significantly protected for those who are walkers, than those who are non walkers. Similarly mobility statistically significantly protective from falls among those who were mobile than those who were non mobile. The constant factor was included in all the univariate analysis.

Table 7: The multivariate regression analysis of all the variables while controlling for the confounders.[a,b]

Variable	B(SE)	OR(95% CI)	P value
Vocation	-5.04(1.60)	0.006(0.00, 0.14)	0.002
Pressure ulcer	5.24(2.24)	189.88(2.35, 15317.86)	0.01
History of fall	1.16(1.15)	3.20(0.33, 30.85)	0.31
Number of fall	-1.24(1.24)	0.28(0.025, 3.30)	0.31

[a]=All regression models had constant included in the analysis.

[b]= Confounders of age, type of ambulation and the type of orthosis were controlled in every multivariate regression analysis.

Table 7 presents the multivariate logistic regression. In all the multiple regression analysis the variables of age, type of ambulation and type of orthosis were controlled as confounders because they were either statistically significantly different in the bivariate analysis or in our clinical experience. History of falls and number of falls lost their significance when they were controlled against the confounders. However importantly despite controlling for the confounders, the inability to be mobile was 190 times seen as a risk for developing pressure ulcers among those who were not walking. We also found that being mobile statistically significantly protected the participant from not being in a vocation.

Table 8: The statistically significant variables in the final risk model [a,b]

Variable	B(SE)	OR(95% CI)	P value
Vocation	4.65 (1.23)	104.682 (9.33, 1174.195)	0.000
Ulcer	-3.69 (1.23)	0.02 (0.002, 0.27)	0.003
History of fall	-0.45 (2.11)	0.63 (0.01, 40.28)	0.83
Number of fall	0.14 (2.22)	1.15 (0.015, 90.59)	0.95

[a]=All regression models had constant included in the analysis.

[b]= Hosmer and Lemeschow = Chi square = 2.05, DF = 3 and P value 0.56

Table 8 represents the overall importance of the predictive variables in the model. The variables of actively paticipating in a daily vocation and presence of pressure ulcers were statistically significant factors in the model for the prediction of one year outcome. The goodness – of – fit for the final model as interpreted from Hosmer and Lemeschow test is good as the P value is above the alpha value of 0.05.

DISCUSSION

DISCUSSION

This is a cohort study to find the incidence of lower limb fractures among rehabilitated chronic traumatic spinal cord injured patients at or below T10 neurological level. Spinal cord injury causes significant mechano-neurochemical changes in the body, as a result of which sublesional skeletal system undergoes rapid remodeling. This leads to increased rate of bone resorption . Normal muscle tone is under the influence of central nervous system and is regulated by feedback mechanism from the stretch reflex. Specialised sensory organs such as muscle spindles act as receptors to stretch and carry afferent impulses via dorsal root to spinal cord, where it activates the alpha motor neuron to cause contraction of extrafusal muscle fibers. After SCI ,these patients present in spinal shock resulting in flaccid muscle tone which may further minimize the mechanosensation in addition to mechanical unloading which aggravate the bone loss by rapid recruitment of resorption activators(20).

Sublesional fractures are common among spinal cord injury patients. Most of the fractures are associated with trivial trauma while ambulation or transfers. Complications result from fracture in the SCI population leading to increased morbidity and mortality. Complications which are commonly seen include altered fracture healing, delayed union, malunion and nonunion, pressure sores, infection, and osteomyelitis (56). In addition, reduced pain sensation may delay the seeking of medical advice, delays of 1 day to 4 weeks have been reported (45). This may require prolonged immobilization and hospitalization. This may further lead to loss of wages, less social interaction, and reduced quality of life.

In this study, individuals were recruited one year after rehabilitation training .

As the participants were enrolled from a cohort, there were people included who are more than 20 years post rehabilitation to a minimum of one year post rehabilitation. Functional ambulation is the ability to walk with the aid of appropriate assistive devices (orthosis), safely and sufficiently to carry out mobility related activities of daily living(54). Both the groups had been completed functional ambulation from the Rehab institute with an endurance of walking for 500 metres at a speed of 0.3 meters per second. They were all trained in community ambulation, prevention of pressure ulcers and prevention of falls. They are also been given awareness about the benefits of therapeutic standing and functional walking which leads to prevention of further osteoporosis, prevention of muscle contractures, maintenance of body posture and improving the cardiovascular endurance. It was a concern to note that many people failed to continue their walking on a daily basis. A trend of shift to non-walking has been observed after easy access to alternate ambulatory facilities like triwheelers, scooters, powered wheelchair etc.

In this study 46.6% (14 participants) out of the non walkers had stopped walking as they have developed a pressure ulcer. This was observed during home visits. People who use wheelchairs, triwheelers and scooties were failed to do adequate pressure relief techniques like pushups. Prolonged sitting in their work setup without following any pressure relief techniques also had lead to development of pressure ulcers. During home visits , one of the patient who was rehabilitated in the past was observed to have an extensive stage 4 sacral

ulcer. The patient was bed bound and was found to have pallor and loss of weight due to poor nutrition which is a risk factor for subsequent mortality. This trend and it associations between developing pressure sores and failure to continue walking need to be evaluated further to find contributing factors (training issues or change in patient's outlook after rehabilitation) causing it.

20% (6 participants) out of the non walkers stopped walking due to damaged orthosis. It was observed among the patients that due to wear and tear of the orthosis, they failed to follow-up in hospital for repair or replacement. Many of the participants pointed out their difficulty in travelling long distances to the orthotic centre or due to financial constrains. For this reason they had chosen to continue to be on wheelchair and do all their activities independently. It has also been seen that the same has been rectified by the regular home visits which were being conducted by the social workers.

16% (5 participants) out of the non walkers stopped walking due to the sedentary lifestyle. Due to faster means of transport and laziness to walk, wearing orthosis had made people to rely on wheelchairs permanently. Spasticity also contributed 3.3% (1 participant) to non-walking status. 13.3% (4 participants) out of the non walkers stopped there walking due to various other reasons like socio economic problems, stigma related issues and poor motivation . One of the participant which we observed during a home visit, who had been trained well in functional walking had stopped walking due to the stigma and discrimination which he had to face from the local community which lead him to poor motivation and depression.

In this study there was no incidence of fractures observed in both walkers and non walkers who have received the same rehabilitation training. Thus there were no primary outcome noted in either groups. However many of the secondary outcomes showed a statistically significant difference between the group that was functionally walking and those who were non walkers. Among the secondary outcomes, the history of fall, pressure ulcers and actively participating in a daily vocation was statistically significantly different between both the groups. The number of falls however were statistically not significant with both the groups. Furthermore it is seen that number of participants who were non walkers had more falls. In addition pressure ulcers were statistically significant for those who were non walkers. On the other hand the participants who were walking had occupied themselves actively in a daily vocation which is statistically significant. It was interesting to find out that falls were common among non walkers which can lead to risk of fractures. This gives a future scope for this study to look forward to finding out the risk factors for falls and what helped the walkers to have less falls.

COMPARISON WITH THE EXISTING LITERATURES

Gifre L et al in their study observed 25% incidence of fractures with a fracture rate of 2.9 fractures per 100 patient-years from a 10 year follow up cohort study (5). Many literature shows high incidence of fractures after SCI. In the Indian population SCI patients are rehabilitated at the earliest and depending upon their neurological level they are rehabilitated. People who are under T10 neurological level are trained in functional walking using orthosis. As they are early rehabilitated in therapeutic standing as well as

functional walking , the incidence of fractures among them are very less. As the current study was held for only one year with a small sample size of 70, it can be studied over a larger period of time with larger samples to determine the incidence of fractures.

CLINICAL APPLICATION

There was a paradigm shift among people who were rehabilitated with functional walking to be permanent non walkers. There are many factors contributing to this paradigm shift which has been mentioned in previous sections. Though the primary outcome of this study was to find fracture incidence; there was none occurred probably due to small sample size and short duration. However it draws our attention to bring it to the community and to the medical fraternity about the importance of functional walking and the benefits of it. Through the observations from the secondary outcome, it has been also stressed that there is a risk of fall more among non walker which can lead to fractures. These paradigm shift and incidence in risk of fall, foreground another study to find factors contributing to it and to develop preventive measures. It is very important for a disabled person to engage in any form of vocation for his day to day earnings as well as to keep him occupied and accepted in the society. In this study, among the walkers 97.5% were actively involved in any form of vocation. Hence functional ambulation becomes a very importantant part of life for a paraplegic who has the potential to walk.

LIMITATIONS

- Proposed sample size was 184. We could recruit only 70 patients in either arm. Failure to get the primary outcome could be due to less sample size.
- The proposed duration was one year which also could have caused absent primary outcome.

CONCLUSION

CONCLUSION

The background of conducting this study was to compare with the existing evidences and literatures , that the incidence of fractures after spinal cord injury post rehabilitation in our population is less. There has been a paradigm shift in the people who are functionally walking to a permanent non walker status in the current scenario . The attempt made in this study will bring much scope in bringing more awareness to the patients, doctors, therapists and the social workers .

Following conclusions were obtained in this study

- No incidence of fractures noted in either groups.
- 57.14% of the participants are functionally walking following the rehabilitation training in the study.
- Non walkers are more at risk of falls than walkers.

FUTURE RESEARCH

- It was a concern through this study that the history of falls and the risk associated among walkers and non walkers were identified. This gives a scope to the researchers to study on the falls and the risk associated which can contribute to fractures.
- It would be ideal to conduct the study over a larger period of time with a larger sample size.

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ANNEXURE

OFFICE OF RESEARCH
INSTITUTIONAL REVIEW BOARD (IRB)
CHRISTIAN MEDICAL COLLEGE, VELLORE, INDIA

Dr. B.J. Prashantham, M.A., M.A., Dr. Min (Clinical)
Director, Christian Counseling Center,
Chairperson, Ethics Committee.

Dr. Anna Benjamin Pulimood, M.B.B.S., MD., Ph.D.,
Chairperson, Research Committee & Principal

Dr. Biju George, M.B.B.S., MD., DM.,
Deputy Chairperson,
Secretary, Ethics Committee, IRB
Additional Vice-Principal (Research)

March 31, 2017

Dr. Naveen Cherian Thomas,
PG Registrar,
Department of PMR,
Christian Medical College,
Vellore - 632 004.

Sub: **Fluid Research Grant NEW PROPOSAL:**
Incidence of lower limb fractures in rehabilitated chronic traumatic spinal cord injury patients of T10 neurological level and below.
Dr. Naveen Cherian Thomas, Employment Number: 21311, PG Registrar, Dept. of PMR, Dr. Jacob George, Professor, Employment Number-30268, Dr. Guru Nagarajan, Selection grade social worker, Employment no- 13330, Mr. Elango. A, Employment no-13546, Selection grade social worker, Department of Physical Medicine and Rehabilitation. Ms .Mahasampath Gowri S, Senior Demonstrator, Department of Biostatistics..

Ref: IRB Min No: 10511 [OBSERVE] dated 01.02.2017

Dear Dr. Naveen Cherian Thomas,

I enclose the following documents:-

1. Institutional Review Board approval 2. Agreement

Could you please sign the agreement and send it to Dr. Biju George, Addl. Vice Principal (Research), so that the grant money can be released.

With best wishes,

Dr. Biju George
Secretary (Ethics Committee)
Institutional Review Board

Dr. BIJU GEORGE
MBBS., MD., DM.
SECRETARY - (ETHICS COMMITTEE)
Institutional Review Board,
Christian Medical College, Vellore - 632 002.

Cc: Dr. Jacob George, Dept. of PMR, CMC, Vellore

Ethics Committee Blue, Office of Research, 1st Floor, Carman Block, Christian Medical College, Vellore, Tamil Nadu 632 002
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OFFICE OF RESEARCH
INSTITUTIONAL REVIEW BOARD (IRB)
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Ref: IRB Min No: 10511 [OBSERVE] dated 01.02.2017

Dear Dr. Naveen Cherian Thomas,

The Institutional Review Board (Blue, Research and Ethics Committee) of the Christian Medical College, Vellore, reviewed and discussed your project titled "Incidence of lower limb fractures in rehabilitated chronic traumatic spinal cord injury patients of T10 neurological level and below " on February 01st 2017.

The Committee reviewed the following documents:

1. IRB Application format
2. Cv's of Drs. Jeena, Aniket, Jeyanta, Margaret, Niranjan and Premila.
3. Informed Consent.
4. No. of documents 1 - 3.

The following Institutional Review Board (Blue, Research & Ethics Committee) members were present at the meeting held on February 01st 2017 in the Jacob Chandy Hall, Paul Brand Building, Christian Medical College, Vellore 632002.

Ethics Committee Blue, Office of Research, 1st Floor, Carman Block, Christian Medical College, Vellore, Tamil Nadu 632 002
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Chairperson, Research Committee & Principal

Dr. Biju George, M.B.B.S., MD., DM.,
Deputy Chairperson,
Secretary, Ethics Committee, IRB
Additional Vice-Principal (Research)

Name	Qualification	Designation	Affiliation
Dr. Biju George	MBBS, MD, DM	Professor, Haematology, Research), Additional Vice Principal , Deputy Chairperson (Research Committee), Member Secretary (Ethics Committee), IRB, CMC, Vellore	Internal, Clinician
Dr. Anuradha Rose	MBBS, MD, MHSC (Bioethics)	Associate Professor, Community Health, CMC, Vellore	Internal, Clinician
Dr. Ratna Prabha	MBBS, MD (Pharma)	Associate Professor, Clinical Pharmacology, CMC, Vellore	Internal, Pharmacologist
Dr. Rajesh Kannangai	MD, PhD.	Professor, Clinical Virology, CMC, Vellore	Internal, Clinician
Rev. Joseph Devaraj	BSc, BD	Chaplaincy Department, CMC, Vellore	Internal, Social Scientist
Mr. C. Sampath	BSc, BL	Advocate, Vellore	External, Legal Expert
Dr. Visalakshi. J	MPH, PhD	Lecturer, Biostatistics, CMC, Vellore	Internal, Statistician
Dr. Jayaprakash Muliyil	BSc, MBBS, MD, MPH, Dr PH (Epid), DMHC	Retired Professor, Vellore	External, Scientist &Epidemiologist
Ms. Grace Rebekha	M.Sc., (Biostatistics)	Lecturer, Biostatistics, CMC, Vellore	Internal, Statistician
Mrs. Pattabiraman	BSc, DSSA	Social Worker, Vellore	External, Lay Person
Mrs. Sheela Durai	MSc Nursing	Professor, Medical Surgical Nursing, CMC, Vellore	Internal, Nurse
Dr. Inian Samarasam	MS, FRCS, FRACS	Professor, Surgery, CMC, Vellore	Internal, Clinician

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Deputy Chairperson,
Secretary, Ethics Committee, IRB
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Dr. Santhanam Sridhar	MBBS, DCH, DNB	Professor, Neonatology, CMC, Vellore	Internal, Clinician
Dr. Vivek Mathew	MD (Gen. Med.) DM (Neuro) Dip. NB (Neuro)	Professor, Neurology, CMC, Vellore	Internal, Clinician
Dr Sneha Varkki	MBBS, DCH, DNB	Professor, Paediatrics, CMC, Vellore	Internal, Clinician
Dr. Sathish Kumar	MBBS, MD, DCH	Professor, Child Health, CMC, Vellore	Internal, Clinician

We approve the project to be conducted as presented.

Kindly provide the total number of patients enrolled in your study and the total number of withdrawals for the study entitled: "Incidence of lower limb fractures in rehabilitated chronic traumatic spinal cord injury patients of T10 neurological level and below" on a monthly basis. Please send copies of this to the Research Office (research@cmcvellore.ac.in).

Fluid Grant Allocation:

A sum of 35,000/- INR (Rupees Thirty Five thousand Only) will be granted for 24 months

Yours sincerely,

Dr. Biju George
Secretary (Ethics Committee)
Institutional Review Board

Dr. BIJU GEORGE
MBBS., MD., DM.
SECRETARY - (ETHICS COMMITTEE)
Institutional Review Board,
Christian Medical College, Vellore - 632 002.

IRB Min No: 10511 [OBSERVE] dated 01.02.2017

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INFORMATION SHEET FOR INFORMED CONSENT

Study Titles: Incidence of lower limb fractures among rehabilitated traumatic spinal cord injury patients of T10 neurological level or below.

You are requested to participate in a study to find out the incidence of lower limb fractures among rehabilitated traumatic spinal cord injury patients of T10 neurological level or below .The final conclusion will be made after comparing the completion of the study.

What is spinal cord injury? Spinal Cord Injury (SCI) refers to damage to the spinal cord that causes changes in its function which could be either temporary or permanent. These changes translate into inability to control the use of voluntary muscles, inability to register and organize sensory information and dysfunction in involuntary nervous function in many parts of the body. Long bone fractures are one of the main complications in SCI. Most of it are caused by trivial falls due to brittle bones, later on leading to further complications and increased death rate.

Rehabilitation Medicine in SCI patients has become a vital role in preventing complications and helping the patients to have the same life expectancy as normal people. One of the major interventions include functional ambulation. Functional ambulation is the ability to walk with the aid of appropriate assistive devices, safely and sufficiently to carry out mobility related activities of daily living.

Does this study have any side effects? No side effects.

If you take part what will you have to do?

- If you agree to participate in this study, you will be interviewed first and datas will be collected by using a questionnaire method.
- People who are walking regularly with the orthosis will be assessed and walking distance will be measured in metres.
- Then you will be followed up after 1 year either through rehab mela/home visits to find out the incidence of fractures and data's will be collected again.
- Finally the incidence of fractures will be found out statistically through the data collected
- .No blood tests or other invasive tests will be required for this study.

Will you have to pay for the study? No need to pay anything for the study.

What happens after the study is over? The final results of this study will be interpreted at the end of 2 years. If we come to a conclusion that the study is beneficial, we will be able to use this information and emphasize more on functional ambulation in paraplegics to reduce the incidence of fractures.

Will your personal details be kept confidential? The results of this study will be published in a medical journal, but your identity will not be revealed in any manner.

However, the images may be reviewed by other specialists associated with the study without your additional permission.

If you have any further questions, please ask:

Dr. Naveen Cherian Thomas

Dept. of Physical Medicine and Rehabilitation

C.M.C. Vellore Ph: 9446053095, Email: naveenct@gmail.com

QUESTIONNAIRE

Date:_____

1) Name :

2) Hospital ID :

3) Age :

4) Sex :

5) Address :

6) Date of injury :

7) Date of discharge from Rehab :

8) Diagnosis :

9)Mobile ☐ Non-Mobile ☐

If mobile then - wheelchair ☐ **ORTHOSIS** ☐ **TRICYCLE** ☐ other ☐

10)Ambulation :

1)Community ambulators ☐ 2)Household ambulators ☐

3)Exercise ambulators ☐ 4) Non ambulators ☐

10) Walking distance with orthosis-…….. metres

11) History of Fracture after SCI rehabilitation : Yes ☐ No ☐

If yes, then Number of fractures:

12) Time of fracture after rehabilitation …….years ……..months

13) Location of fracture _____

14) Treatment conservative ☐ surgical ☐

CLINICAL EXAMINATION

1. Range of motion of lower limbs by goniometer: Passive ROM

HIP JOINT		Right	Left
	Abduction /Adduction		
	Flexion / Extension		
	Internal/ External rotation		
KNEE JOINT			
	Flexion/ Extension		
ANKLE JOINT			
	Dorsiflexion/ Plantar flexion		

2. Limb length discrepancy by measuring tape: Symmetrical ☐ Asymmetrical ☐

Apparent length ☐ true length ☐

3. Swellings **soft** ☐ bony hard ☐

Site of swelling _____

4. Pseudo joints in lower limbs: Present ☐ Absent ☐

If yes: Site_____

Side: Right ☐ Left ☐

Any new fractures or neglected fractures found out after clinical examination- Yes ☐ No ☐

Walking Index for Spinal Cord Injury (WISCI II)

Physical limitation for walking secondary to impairment is defined at the person level and indicates the ability of a person to walk after spinal cord injury. The development of this assessment index required a rank ordering along a dimension of impairment, from the level of most severe impairment (0) to least severe impairment (20) based on the use of devices, braces and physical assistance of one or more persons. The order of the levels suggests each successive level is a less impaired level than the former. The ranking of severity is based on the severity of the impairment and not on functional independence in the environment. The following de®nitions standardize the terms used in each item:

Physical assistance: assistance.	`Physical assistance of two persons' is moderate to maximum
	`Physical assistance of one person' is minimal assistance.
Braces:	`Braces' means one or two braces, either short or long leg.
	(Splinting of lower extremities for standing is considered long leg bracing).
	`No braces' means no braces on either leg.
Walker:	`Walker' is a conventional rigid walker without wheels.
Crutches:	`Crutches' can be Lofstrand (Canadian) or axillary.
Cane:	`Cane' is a conventional straight cane.

Level Description

Client is unable to stand and/or participate in assisted walking.

0) Ambulates in parallel bars, with braces and physical assistance of two persons, less than 10 meters.
1) Ambulates in parallel bars, with braces and physical assistance of two persons, 10 meters.
2) Ambulates in parallel bars, with braces and physical assistance of one person, 10 meters.
3) Ambulates in parallel bars, no braces and physical assistance of one person, 10 meters.
4) Ambulates in parallel bars, with braces and no physical assistance, 10 meters.
5) Ambulates with walker, with braces and physical assistance of one person, 10 meters.
6) Ambulates with two crutches, with braces and physical assistance of one person, 10 meters.
7) Ambulates with walker, no braces and physical assistance of one person, 10 meters.
8) Ambulates with walker, with braces and no physical assistance, 10 meters.
9) Ambulates with one cane/crutch, with braces and physical assistance of one person, 10 meters.
10) Ambulates with two crutches, no braces and physical assistance of one person, 10 meters.
11) Ambulates with two crutches, with braces and no physical assistance, 10 meters.
12) Ambulates with walker, no braces and no physical assistance, 10 meters.
13) Ambulates with one cane/crutch, no braces and physical assistance of one person, 10 meters.
14) Ambulates with one cane/crutch, with braces and no physical assistance, 10 meters.
15) Ambulates with two crutches, no braces and no physical assistance, 10 meters.
16) Ambulates with no devices, no braces and physical assistance of one person, 10 meters.
17) Ambulates with no devices, with braces and no physical assistance, 10 meters.
18) Ambulates with one cane/crutch, no braces and no physical assistance, 10 meters.
19) Ambulates with no devices, no braces and no physical assistance, 10 meters.

Scoring Sheet (WISCI II)

Patient Name _____ ***Date*** _____

Check descriptors which apply to current walking performance, then assign the highest level of walking performance. *(In scoring a level, one should choose the level at which the patient is safe as judged by the therapist, with patient's comfort level described. If devices other than stated in the standard definitions are used, they should be documented as descriptors. If there is a discrepancy between two observers, the higher level should be chosen.)*

Descriptors

Gait: reciprocal ____; swing through

Devices	Braces	Assistance	Patient reported comfort level
// bars < 10 mtrs	Long Leg Braces- Uses 2 Uses 1	Max assist x 2 people	Very comfortable
//bars 10 mtrs	Short Leg Braces- Uses 2 Uses 1	Min/Mod assist x 2 people	Slightly comfortable
Walker- Standard Rolling Platform	Locked at knee____ Unlocked at knee____	Min/Mod assist x 1 person	Neither comfortable nor uncomfortable
Crutches- Uses 2 Uses 1	Other		Slightly uncomfortable
Canes- Quad Uses 2 Uses 1			Very Uncomfortable
No devices	No braces	No assistance	

WISCI Levels

Level	Devices	Braces	Assistance	Distance
0				Unable
1	Parallel bars	Braces	2 persons	Less than 10 meters
2	Parallel bars	Braces	2 persons	10 meters
3	Parallel bars	Braces	1 person	10 meters
4	Parallel bars	No braces	1 person	10 meters
5	Parallel bars	Braces	No assistance	10 meters
6	Walker	Braces	1 person	10 meters
7	Two crutches	Braces	1 person	10 meters
8	Walker	No braces	1 person	10 meters
9	Walker	Braces	No assistance	10 meters
10	One cane/crutch	Braces	1 person	10 meters
11	Two crutches	No braces	1 person	10 meters
12	Two crutches	Braces	No assistance	10 meters
13	Walker	No braces	No assistance	10 meters
14	One cane/crutch	No braces	1 person	10 meters
15	One cane/crutch	Braces	No assistance	10 meters
16	Two crutches	No braces	No assistance	10 meters
17	No devices	No braces	1 person	10 meters
18	No devices	Braces	No Assistance	10 meters
19	One cane/crutch	No braces	No assistance	10 meters
20	No devices	No braces	No assistance	10 meters

Level assigned_____

INFORMED CONSENT FORM

Study Title: Incidence of lower limb fractures among rehabilitated traumatic spinal cord injury patients of T10 neurological level or below.

Study Number: _____

Subject's Initials: _____

Subject's Name: _____

Date of Birth / Age: _____

(Subject)

I. I confirm that I have read and understood the information sheet dated _____ (for the above study and have had the opportunity to ask questions. [ ]

II. I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. [ ]

III. I understand that doctors in CMC, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published.

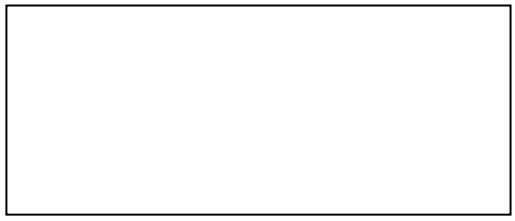
IV. I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s). [ ]

V. I voluntarily agree to take part in the above study. [ ]

Signature (or Thumb impression) of the Subject/Legally Acceptable Date: _____/_____/_____

Signatory's Name: _____ Signature:

Or



Representative: _____ Date: _____/_____/_____ Signatory's Name: _____

Signature of the Investigator: _____ Date:

_____/_____/_____ Study Investigator's Name: _____

DATA SHEET

sr	date	name	hospn	age	sex	doi	dod	diagnosis	nobilitbulati	ona	walkdist	hof	wisci	hip	lnormkneenormankle	n1n	lld	pj	nf	date2nd	jobilitbulana	alkdist	hof1	visclhip1ormneeormkkornlld1pj1	nf1
1	18/02/2017	LAKSHMAN	757675B	37	1	26/06/1999	08/02/2000	L1 ASIA A PA	2	1	1	400	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	400	FALSE	1	1	1	1	1	1	1	2	FALSE
2	12/06/2017	PRIYA JASN	945133A	38	2	23/12/1998	12/06/1999	T10 ASIA C P	2	1	1	400	FALSE	1	1	1	1	1	2	FALSE	13/06/2018	2	1	1	400	FALSE	1	1	1	1	1	1	1	2	FALSE
3	18/02/2017	KARUNANI	034515C	59	1	30/06/2001	09/02/2002	T11 ASIA A P	2	1	1	200	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	200	FALSE	1	1	1	1	1	1	1	2	FALSE
4	18/02/2017	HARI	170174F	33	1	02/04/2012	19/06/2012	L2 ASIA A PA	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
5	18/02/2017	DURAIRAJ	209514B	50	1	23/07/1994	12/11/1996	L2 ASIA A PA	2	1	1	2000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	2000	FALSE	1	1	1	1	1	1	1	2	FALSE
6	18/02/2017	DAMODAR	969232C	28	1	09/11/2006	17/08/2007	L3 ASIA B PA	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	16/02/2008	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
7	18/02/2017	SATHYA	595730C	27	1	09/05/2005	15/07/2005	T12 ASIA C P	2	1	1	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
8	18/02/2017	KRISHNAN	903299A	59	1	22/09/1990	06/03/1991	L1 ASIA A PA	2	1	1	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
9	18/02/2017	KUMAR G	353802C	45	1	01/12/1997	24/03/2004	T11 ASIA C P	2	2	1	10	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	2	1	10	FALSE	1	1	1	1	1	1	1	2	FALSE
10	18/02/2017	RAMESH	688635F	40	1	06/10/2013	14/03/2014	T11 ASIA C P	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
11	18/02/2017	NAGARAJ S	891859D	39	1	25/02/2011	03/08/2011	T12 ASIA C P	2	1	1	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
12	18/02/2017	RADAKRISH	058499B	42	1	28/08/1992	13/03/1993	T11 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	06/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
13	08/02/2017	RAMADOS	909073D	27	1	04/03/2010	08/10/2011	L3 ASIA B PA	2	1	1	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
14	18/02/2017	BHARATRA	748219A	41	1	25/04/1988	20/11/1989	L2 ASIA C PA	2	1	1	2000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	2000	FALSE	1	1	1	1	1	1	1	2	FALSE
15	18/02/2017	BHASKAR	967222F	34	1	28/02/2015	24/07/2015	L1 ASIA A PA	2	3	1	50	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	3	1	50	FALSE	1	1	1	1	1	1	1	2	FALSE
16	18/02/2017	VELUSWAN	992747D	22	1	24/09/2011	16/11/2012	T12 ASIA C P	2	1	1	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
17	18/02/2017	SATHISH K	747042D	31	1	01/12/1989	22/11/1997	L1 ASIA A PA	2	1	1	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
18	18/02/2017	THIYAGU	777159D	29	1	09/06/2010	01/11/2011	T10 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
19	18/02/2017	RAJESH R	923585D	23	1	16/04/2011	28/10/2011	T12 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
20	18/02/2017	VIJAYAKUN	032254F	56	1	21/09/2011	23/01/2012	T12 ASIA B P	2	3	1	50	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	3	1	50	FALSE	1	1	1	1	1	1	1	2	FALSE
21	18/02/2017	SHANKAR	829390B	36	1	14/12/1999	28/12/1999	T12 ASIA C P	2	1	4	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	4	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
22	18/02/2017	AMAVASAI	859277B	45	1	28/02/2001	23/11/2001	T11 ASIA A P	2	1	1	400	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	400	FALSE	1	1	1	1	1	1	1	2	FALSE
23	18/02/2017	VELMURUG	231865F	44	1	24/09/2011	16/11/2012	L3 ASIA A PA	2	1	1	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
24	18/02/2017	AMRITHAL	571047B	44	1	15/12/1997	15/01/1999	T12 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
25	18/02/2017	MANIKANE	711894D	31	1	01/01/2006	07/09/2010	L2 ASIA A PA	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	5000	FALSE	1	1	1	1	1	1	1	2	FALSE
26	18/02/2017	VYKUNDAN	167131C	35	1	01/06/2001	07/10/2002	T10 ASIA C P	2	1	1	5000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	5000	FALSE	1	1	1	1	1	1	1	2	FALSE
27	18/02/2017	SHANKAR	165831B	39	1	01/09/1993	05/02/1994	L5 ASIA C PA	2	1	2	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
28	18/02/2017	SHANMUKI	209312C	59	1	05/10/2002	17/03/2003	T11 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
29	18/02/2017	SIVAKAVI	917852F	37	1	20/08/2014	25/10/2014	L3 ASIA B PA	2	1	2	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	2	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
30	18/02/2017	JESU INBA	035115B	50	1	01/03/1989	26/03/1993	T11 ASIA PAI	2	2	1	50	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	2	1	50	FALSE	1	1	1	1	1	1	1	2	FALSE
31	18/02/2017	VENKATAC	191594F	30	1	26/05/2013	27/09/2013	L1 ASIA B PA	2	1	1	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
32	18/02/2017	GUNASEKA	115757B	48	1	10/05/1993	06/11/1993	T12 ASIA C P	2	1	4	1000	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	2	1	4	1000	FALSE	1	1	1	1	1	1	1	2	FALSE
33	24/05/2017	PRAKASH	498968B	48	1	14/03/1997	25/10/1997	T12 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	30/05/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
34	18/06/2017	UDAYARAJ	100305G	30	1	10/11/2014	23/02/2015	T12 ASIA PAI	2	1	1	500	FALSE	1	1	1	1	1	2	FALSE	20/06/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	2	FALSE
35	18/02/2017	RAM MOO	615886B	50	1	22/05/1998	16/11/1998	T10 ASIA A P	2	1	1	200	FALSE	1	1	1	1	1	2	FALSE	16/02/2018	1				FALSE	2	1	1	1	1	1	1	2	FALSE

sr	date	name	hospn	age	sex	doi	dod	diagnosis	nobilitbulati	ona	walkdist	hof	wisci	hip	lnorm	kneenormankle	n1nu	lld	pj	nf	date2nd	obilitbulaona	walkdist	hof1	visci	hip1	ornnee	ormkle	ornlld	1pj1	nf1
1	18/02/2017	LAKSHMAN	757675B	37	1	26/06/1999	08/02/2000	L1 ASIA A PA	2	1	1	400	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	400	FALSE	1	1	1	1	1	1	1	1	2	FALSE
2	12/06/2017	PRIYA JASM	945133A	38	2	23/12/1998	12/06/1999	T10 ASIA C P	2	1	1	400	FALSE	1	1	1	1	1	1	1	1	2	FALSE	13/06/2018	2	1	1	400	FALSE	1	1	1	1	1	1	1	1	2	FALSE
3	18/02/2017	KARUNANI	034515C	59	1	30/06/2001	09/02/2002	T11 ASIA A P	2	1	1	200	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	200	FALSE	1	1	1	1	1	1	1	1	2	FALSE
4	18/02/2017	HARI	170174F	33	1	02/04/2012	19/06/2012	L2 ASIA A PA	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
5	18/02/2017	DURAIRAJ	209514B	50	1	23/07/1994	12/11/1996	L2 ASIA A PA	2	1	1	2000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	2000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
6	18/02/2017	DAMODAR	969232C	28	1	09/11/2006	17/08/2007	L3 ASIA B PA	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2008	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
7	18/02/2017	SATHYA	595730C	27	1	09/05/2005	15/07/2005	T12 ASIA C P	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
8	18/02/2017	KRISHNAN	903299A	59	1	22/09/1990	06/03/1991	L1 ASIA A PA	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
9	18/02/2017	KUMAR G	353802C	45	1	01/12/1997	24/03/2004	T11 ASIA C P	2	2	1	10	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	2	1	10	FALSE	1	1	1	1	1	1	1	1	2	FALSE
10	18/02/2017	RAMESH	688635F	40	1	06/10/2013	14/03/2014	T11 ASIA C P	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
11	18/02/2017	NAGARAJ S	891859D	39	1	25/02/2011	03/08/2011	T12 ASIA C P	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
12	18/02/2017	RADAKRISH	058499B	42	1	28/08/1992	13/03/1993	T11 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	06/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
13	08/02/2017	RAMADOS	909073D	27	1	04/03/2010	08/10/2011	L3 ASIA B PA	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
14	18/02/2017	BHARATRA	748219A	41	1	25/04/1988	20/11/1989	L2 ASIA C PA	2	1	1	2000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	2000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
15	18/02/2017	BHASKAR	967222F	34	1	28/02/2015	24/07/2015	L1 ASIA A PA	2	3	1	50	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	3	1	50	FALSE	1	1	1	1	1	1	1	1	2	FALSE
16	18/02/2017	VELUSWAM	992747D	22	1	24/09/2011	16/11/2012	T12 ASIA C P	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
17	18/02/2017	SATHISH KI	747042D	31	1	01/12/1989	22/11/1997	L1 ASIA A PA	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
18	18/02/2017	THIYAGU	777159D	29	1	09/06/2010	01/11/2011	T10 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
19	18/02/2017	RAJESH R	923585D	23	1	16/04/2011	28/10/2011	T12 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
20	18/02/2017	VIJAYAKUM	032254F	56	1	21/09/2011	23/01/2012	T12 ASIA B P	2	3	1	50	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	3	1	50	FALSE	1	1	1	1	1	1	1	1	2	FALSE
21	18/02/2017	SHANKAR	829390B	36	1	14/12/1999	28/12/1999	T12 ASIA C P	2	1	4	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	4	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
22	18/02/2017	AMAVASAI	859277B	45	1	28/02/2001	23/11/2001	T11 ASIA A P	2	1	1	400	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	400	FALSE	1	1	1	1	1	1	1	1	2	FALSE
23	18/02/2017	VELMURUC	231865F	44	1	24/09/2011	16/11/2012	L3 ASIA A PA	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
24	18/02/2017	AMRITHALI	571047B	44	1	15/12/1997	15/01/1999	T12 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
25	18/02/2017	MANIKANE	711894D	31	1	01/01/2006	07/09/2010	L2 ASIA A PA	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	5000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
26	18/02/2017	VYKUNDAM	167131C	35	1	01/06/2001	07/10/2002	T10 ASIA C P	2	1	1	5000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	5000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
27	18/02/2017	SHANKAR	165831B	39	1	01/09/1993	05/02/1994	L5 ASIA C PA	2	1	2	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
28	18/02/2017	SHANMUKI	209312C	59	1	05/10/2002	17/03/2003	T11 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
29	18/02/2017	SIVAKAVI	917852F	37	1	20/08/2014	25/10/2014	L3 ASIA B PA	2	1	2	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	2	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
30	18/02/2017	JESU INBAM	035115B	50	1	01/03/1989	26/03/1993	T11 ASIA PAI	2	2	1	50	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	2	1	50	FALSE	1	1	1	1	1	1	1	1	2	FALSE
31	18/02/2017	VENKATAC	191594F	30	1	26/05/2013	27/09/2013	L1 ASIA B PA	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	1	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
32	18/02/2017	GUNASEKA	115757B	48	1	10/05/1993	06/11/1993	T12 ASIA C P	2	1	4	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	2	1	4	1000	FALSE	1	1	1	1	1	1	1	1	2	FALSE
33	24/05/2017	PRAKASH	498968B	48	1	14/03/1997	25/10/1997	T12 ASIA A P	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	30/05/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
34	18/06/2017	UDAYARAJ	100305G	30	1	10/11/2014	23/02/2015	T12 ASIA PAI	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE	20/06/2018	2	1	1	500	FALSE	1	1	1	1	1	1	1	1	2	FALSE
35	18/02/2017	RAM MOOI	615886B	50	1	22/05/1998	16/11/1998	T10 ASIA A P	2	1	1	200	FALSE	1	1	1	1	1	1	1	1	2	FALSE	16/02/2018	1				FALSE	2	1	1	1	1	1	1	1	2	FALSE